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CONTENTS OF VOL. II.

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DIRECTIONS TO THE BINDER.

Plate I., (Vol. I.)	to face page	284	Plate XIV., XV.,	to face page	182
,, II.,	,,	30	,, XVI.,	,,	217
,, III.,	,,	55	,, XVII-XX.,	,,	230
,, IV.-X.,	,,	109	,, XXI.,	,,	235
,, XI., XII.,	,,	162	,, XXII.,	,,	237
,, XIII.,	,,	170	,, XXIII.,	,,	260

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ROYAL GEOLOGICAL SOCIETY OF IRELAND.

I.—On the Subdivisions of the Carboniferous Formation in Central Ireland. By J. Beete Jukes, M. A., F. R. S.

[Read March 13, 1866.]

THE CENTRAL PLAIN OF IRELAND—DRIFT AND BOG.

The low land which stretches across the centre of Ireland, from the neighbourhood of Dublin Bay to that of Galway, is largely covered with that description of drift which is commonly known as "limestone gravel."

This consists chiefly of pebbles of Carboniferous Limestone of all sizes, from a quarter of an inch to a foot or more in diameter, embedded in a dirty black earthy clay, variously interstratified in some places with irregular beds or patches of lighter coloured sand.

This limestone gravel spreads over all the lower ground with an irregular thickness, that very often attains from 30 to 40 feet, and probably more; and it sweeps in local patches up the sides of the adjacent hills, sometimes to a height of 1000 feet above the level of the sea.

Over all the lower grounds this limestone gravel almost entirely conceals the subjacent rocks. We can only judge of the nature of those rocks by examining the few bare knolls of them that occur at intervals, or their exposures in scattered quarries, where the "head" of gravel is sufficiently thin to allow of the rock being reached. There are scarcely any cuttings even on the line of the Midland Railway, or its subordinate lines, in which solid rocks are exposed.

Great tracts of this low, drift-covered district are coated with extensive "peat mosses," or bogs—a number of which are often spoken of collectively as the great Bog of Allen. The peat is often forty feet thick; and, when stripped off, is found generally to rest upon that white, mealy substance, full of fresh-water shells, which is known as "shell

marl." A grey clay, one or two feet thick, often lies below the shell marl, between it and the coarse limestone gravel. These substances show that the bogs spread for the most part over the sites of old shallow lakes.

CHANGE OF STRUCTURE IN THE CARBONIFEROUS LIMESTONE.

The Carboniferous Formation, the structure of which is well shown in the hills of the Queen's County, Kilkenny, Tipperary, Limerick, and Clare, on the south, is greatly concealed in the central district by this cover of "drift" and bog; and when it rises from it on the north into the hills of Mayo, Leitrim, and Fermanagh, its character is found to be very different from that which it had on the south.

The problem we have to solve is, whereabouts does this change of character commence, what is the exact nature of the change, and how was it produced?

The geologist working from the north, who has learned his lesson from the sections to be seen there, would, of course, be apt to push the northern character into the obscure central district as far south as he could; while his brother workman, who had learned a different lesson in the south, would be equally apt to read the indications he met with by the light of his southern experience as far north as it could be made to guide him.

THE KILKENNY DISTRICT.

The officers of Her Majesty's Geological Survey, some years ago, took the structure of the Kilkenny district as their guide. In that district the Carboniferous Formation can be subdivided into—

Coal measures, black shales, with thin coals and coal plants above; interstratified below with thick layers of fine-grained grey and black grits and flagstones, containing Goniatites, Aviculopecten, Posidonomya, &c., ... 2000 to 3000 feet.

Upper Limestone, pale grey or nearly white limestone, with many fossils, ...	500 to 1000 feet.
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Trusting to the persistency of this type of subdivision, the Carboniferous Formation of the county of Dublin was originally mapped in accordance with it by Mr. Du Noyer, under Dr. Oldham; and the Index Map of the county (published before the construction of the one-inch map) showed Calp and Lower Limestone only in the northern part of the county, while a patch of Upper Limestone was introduced in the southern part of the county, about Belgard, south of Clondalkin.

My very first examination of this supposed Upper Limestone, in the spring of 1851, showed me that it dipped under black shaly beds, which were called Calp, or Middle Limestone, and therefore that the mere lithological characters of the beds were in that district no safe guide to their stratigraphical position.

It was not till the beginning of the year 1859 that I examined the northern part of the county of Dublin, immediately after seeing the Kilkenny Coal-measures, as described in a paper published in vol. viii.* of our "Journal;" and I found that large parts of the rocks, hitherto considered to be Calp, or Middle Limestone, were in reality the lower part of the Coal-measures.

Other patches of Coal-measures were subsequently mapped by Mr. Du Noyer, under my direction, in the county of Dublin, and the adjacent parts of Meath. These Coal-measures rested chiefly on dark earthy limestones, with occasional shaly beds, of the lithological character usually assigned to the Calp; and I concluded that nearly the whole of the Upper Limestone of the county of Dublin and the neighbourhood had assumed this earthy and calpy character.

No very definite thickness, however, could be assigned to this upper subdivision; and thick beds of good grey limestone were observable in some places, as in the Milverton quarries, near Skerries, at no great distance from the base of the Coal-measures; while in other places the earthy and calpy characters prevailed over much wider areas, and apparently, therefore, through a much greater thickness of beds.

The singular conglomerates of Silurian fragments and blocks found in the Carboniferous Limestone at Rush were, according to our then grouping of the rocks, placed in the Upper Limestone; while similar conglomerates on the shore, north of Lough Shinny, were, solely in consequence of the lithological character of the associated limestone, assigned to the Lower Limestone.

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* "Journal of the Geological Society of Dublin."

THINNING OF THE LIMESTONE MUST BE A DEFICIENCY OF THE LOWER BEDS, NOT A DEFECT IN THE MIDDLE ONES.

The Coal-measures, however, approached in some places very closely to the Silurian rocks, so that very little room was left for any thickness of limestone between the base of the Coal-measures and the local base of the whole Carboniferous formation. If we divide that small thickness into Upper and Lower Limestone, it follows that there had been a dwindling and diminution of the calcareous deposit in that area after it had begun to be formed there. I can see no reason for such a supposition. The individual beds are not thinner there than elsewhere; and there is no evidence in favour of the idea that, when once the waters of the Carboniferous sea spread over any area, the growth and formation of limestone ceased in one part of it, while it progressed in all the surrounding parts. All the available evidence is in favour of the idea that, where the whole limestone is thinner than usual, it is in consequence of the absence of the lower beds, that absence being due to the fact that there was dry land in that particular part of the area, while sea existed in those other parts where the lower beds are found, and where the limestone consequently attained its normal thickness.

Adopting the hypothesis of the gradual depression of an old land, formed chiefly of Silurian rock, beneath the ever-widening waters of the Carboniferous sea, we get a reasonable mode of accounting, not only for the occasional variations in thickness by the absence or presence of the lower beds, but also for much variation in lithological character in beds of the same age. This variation would be the natural result of changes in the various circumstances of deposit, such as proximity or remoteness of land, character of shore, nature of wasting cliffs, influx of streams, and so forth.

Influenced by these considerations, I had long entertained an entire distrust in mere lithological character as evidence of the relative stratigraphical position of different portions of the Carboniferous Limestone, and had withheld from publication several sheets of the one-inch map of the Geological Survey till I could satisfy myself on this point.

DISTRICT S. W. OF DROGHEDA.

Mr. G. V. Du Noyer, in his examination of the country to the S. W. of Drogheda, last year, came upon a district which gives the desired proof, and shows that an entire change may take place within a very few miles in the character of beds on the same geological horizon.

About three miles south-west of Drogheda, at the village of Donore, a patch of Coal-measures commences, of an irregular figure, but about five miles across. These Coal-measures do not contain any beds of coal, but consist of black shales, with beds of yellow or brown sandstone.

Along four miles of the south-eastern margin of this patch of Coal-measures, between Donore and Piercetown, there rise out numerous crags of light grey crystalline thick-bedded limestone, like the Upper Limestone of Kilkenny, or that of Burren in the county of Clare. The

black shales of the Coal-measures rest directly on these limestones, being visible in one place within twenty yards of them.

On approaching Donore from the south, however, some flaggy and shaly beds make their appearance among the upper beds of the limestone; and about a mile to the north of that village black shales, interstratified with thin black flaggy limestones, show themselves between the Coal-measures and the pale grey limestones. These beds may be seen dipping at high angles under the Coal-measures on the banks of the Boyne, about "The Farm," and in the valley of the little brook which runs into the Boyne near that place.

Similar thin flaggy limestones occur on the N. W. side of this patch of Coal-measures, especially about a place called "Yellow Furze," where they are seen in one large quarry to be bent into a sharp anticlinal curve, which has been tilted to the south, so as to make both arms of the curve dip northward—the under one at much the greater angle.

The grey crystalline limestone which rises immediately from under the Coal-measures, to the S. W. of Donore, seems to be separated from them by several hundred feet of these black shaly beds to the northward of the Coal-measure patch, and to die away to the westward, between the black shaly limestones of Yellow Furze and those which are so conspicuous on the banks of the Boyne at Slane Bridge.

All the evidence is in favour of the idea that in this locality a change, rapid but gradual, takes place in the character of the limestones that lie immediately beneath the Coal-measures—the beds in one place being exactly the Calp of Dublin, while in the other they are like the Upper pale grey Limestone of Kilkenny, or that of the Burren country in the county of Clare.

In some places, indeed, these limestone crags beneath the Coal-measures assume all the massive unstratified character of the crags which, in the Lower Limestone of the county of Limerick, acquired with us the cant name of "amorphous limestone."

THE SIX COAL MEASURE PATCHES OF MEATH AND DUBLIN.

Similar alternations of character may be seen in the limestones which spread round the half dozen patches of Coal-measure shales which occur in the south of the county of Meath, and north of the county of Dublin, and to which perhaps we may give the names of the Donore, the Skreen, the Trim, the Summerhill, the Garristown, and The Naul, and Baldongan patches.*

The occurrence of these isolated patches of lower Coal-measures (all devoid of coal), with perhaps another small outlier to the west of Trim, proves all the nearly level-lying limestone which intervenes between

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* On going over the country with Mr. Du Noyer last year, I saw reason to suspect that the three small patches of Coal-measures, hitherto marked as distinct in our maps of North Dublin, were in reality connected—a suspicion confirmed by Mr. Du Noyer on farther examination of the ground.

them and surrounds them to be the Upper Limestone, whatever may be its lithological character.

THE OLD RED SANDSTONE HILLS OF KILLUCAN AND LONGFORD.

The occurrence of Old Red Sandstone on Sion Hill, north of Killucan, would show the limestones surrounding it to belong to the Lower Limestone.

In like manner, if the red sandstones and conglomerates that rise out from beneath the limestone on the low hills of Slievgalry and Lisduff, near Longford, be really Old Red Sandstone, the limestones surrounding them must needs be Lower Limestone.

THE GREY LIMESTONES OF THE MEOUL HILLS.

The hilly ground that runs from about Mullingar to Castlepollard and Loughcrew, near Oldcastle, and encloses so many of the Westmeath lakes, is mostly formed of dark grey limestones, with black shales, having very much of the calpy character, according to Mr. Du Noyer's observations. To the northward of Castlepollard, however, there is a hilly tract, which has caused us some little trouble, but which I believe the facts proved near Drogheda now enable me to understand.

Four miles north of Castlepollard there is a conspicuous crag called Curry rock, a mile to the east of which, a hill called Meoul (pronounced Mwee), rises to a height of 795 feet above the sea. Two miles to the N. N. E. of that is a hill known to the people as Mullaghmeen, 849 feet high. These hills, and the ground immediately round them, are made of pale grey thick-bedded, compact, and crystalline limestone, like that of the Burren of Clare, and the Upper Limestone of Kilkenny. The beds are nearly horizontal, but on the whole dip south at an angle which may, perhaps, be taken to average 5°. This dip, if continuous, would bring the highest bed of Mullaghmeen down to the sea level at a distance of a mile and a half south of its summit. The low ground around the hills is greatly covered with drift; but all Mr. Du Noyer's observations on those beds which are to be seen there, as well as those about Castlepollard, indicate a general southern dip, sometimes at angles of 10° or 20°. The rocks about Castlepollard are the black limestones and shales of the calpy character. All the observable facts, therefore, would go to place the thick light grey limestones of the Meoul hills below the dark grey calpy limestones of the Castlepollard, Multyfarnham, and Mullingar country.

There is the possibility that all these calpy limestones turn over in the obscure low country on the south of the Meoul hills, and dip northwards underneath them. There is, however, no evidence in favour of the supposition; and there is no appearance of any such thickness of calpy beds rising out again on the north sides of the Meoul hills about Lough Sheelin, or anywhere in the neighbourhood. The Ross Castle limestone belongs to the lower division of the limestone, as I shall show presently; and between that limestone and the northern base of Mullaghmeen there is a valley in which little rock is to be seen, and in which

there is certainly no room for the rising up of the great thickness of calpy limestone which is shown in the southern country, unless it rise at a much greater angle than we have any visible example of in the neighbourhood.

The true explanation of the character of the limestone of the Meoul hills is to be sought in that gradual lateral change in the nature of the beds which I have before insisted on. This may be seen in various places as we approach the Meoul hills—as, for instance, about Pakenham Hall, Turbotstown, and Rockbrook on the S. W.; about Tully hill, on the N.W.; and at the cross roads near the junction of the townlands of Ballynacarry, in Westmeath, and Ballinrink, in Meath, on the N. E. In all these places the limestones are irregularly bedded, with irregular platy partings, grey, not black, thin limestones rather than shales, and showing, therefore, a sort of gradation from the pure light-coloured thick-bedded limestones of the Meoul hills into the black earthy limestones and black shales of the surrounding country.

The conclusion, then, which I have finally arrived at is, to look upon these masses of pure light-coloured limestone as great irregular cakes occurring at intervals in the more thin and evenly bedded and more earthy limestones, interstratified with black shales, which occur in the country round them.

The boundaries round these subdivisions of the limestone, as given in the map, do not strictly represent true geological horizons between upper and lower groups of beds, but quite arbitrary boundaries, showing approximately the limits of areas occupied by beds of different lithological character, though perhaps of contemporaneous formation. In adopting this course we are following Sir R. J. Griffith's example, and I believe it will have to be followed in other countries hereafter.

THE OLD RED SANDSTONE OF THE SOUTH-WEST OF IRELAND.

Having thus disposed of the subdivisions of the upper part of the Carboniferous Limestone of Central Ireland, it remains to examine the base of the formation.

Everything shows that in Ireland the true Old Red Sandstone is the proper base of the Carboniferous series. This, which has been for many years the conclusion arrived at by the father of Irish Geology, Sir Richard Griffith, is the opinion, I believe, of every one who is sufficiently acquainted with the geology of Ireland. It was long ago the opinion of Professor John Phillips; and I believe it is the opinion to which every English and Scotch geologist will shortly come, as the only correct interpretation of the structure of Great Britain.

The Old Red Sandstone is magnificently developed in the south-west of Ireland, supporting first the Carboniferous Slate, or Devonian form of the Carboniferous Limestone; then the Carboniferous Limestone itself, in its various modifications, as we trace it from south to north.

The Old Red Sandstone, however, dies away as we proceed from S. W. to N. E., until in Carlow, Kildare, and Dublin, the Carbonife-

rous Limestone rests directly on the Old Granitic and Silurian floor, with only two or three occasional small patches of Red Sandstone and conglomerate at its base, which can be assigned to the Old Red Sandstone. On the west the Old Red Sandstone retains more of its southern importance up to the latitude of Galway Bay. It is well seen on the flanks of Slieve Bloom and Slieve Aughta, where it is still several hundred feet thick. These are obviously the upper beds only of the Cork and Kerry Old Red, the lower thousands of feet having never been deposited on the north.

Beds of Red Sandstone and conglomerate, precisely like the Old Red, rise into small hills from underneath the limestones of the central plain. The low hills called Knockdomney, near Moate, and other patches between Moate and Ferbane and Kilbeggan, are of this character. The hill called Sion Hill, near Killucan, is another example. Near Longford we have Slievegalry and Lisduff hills; in Roscommon, Slieve Bawn; and in eastern Galway, Slievemary, north of Mountbellew; and Slievedart, north of Dunmore—all hills of this structure.

To the south-west of Castlereagh, in Roscommon, is a hill called Slievé O'Flyn, that may possibly be Old Red Sandstone; while north-east of that town are yellow sandstones, apparently interstratified with the lower part of the Carboniferous Limestone.

HYPOTHESIS OF THE DEPRESSION OF AN OLD LAND.

If the red and yellow sandstones, with occasional conglomerates, that become visible in these localities, are true Old Red Sandstone, it follows as an inevitable consequence that the limestones immediately around them belong to the lower part of the Carboniferous Limestone. There is not the slightest particle of evidence in favour of the supposition that there was any thinning out, or deficiency of deposit, *within* the Carboniferous Limestone itself in any part of Ireland that I have yet examined. Wherever there is an undoubted bed of Old Red Sandstone, I feel convinced that the full thickness of something like 3000 feet of Carboniferous Limestone, or equivalent material, once existed over it.

It does not at all follow, however, that wherever there is a bed of Carboniferous Limestone there was once a thickness of 3000 feet of it, not even if there be beds of red sandstone and conglomorate below such beds of Carboniferous Limestone. The legitimate inference with respect to such beds of red sandstone and conglomerate is, that they are not true Old Red Sandstone, but local beds of similar lithological character, deposited in the Carboniferous Limestone, and at some height above its base.

Here the existence of previous land need no longer be accepted as a hypothesis, but may be taken as proved.

That the centre of Ireland, at all events, was at least in part dry land previously to the Carboniferous period, is shown by the occurrence of land plants and shells in the Old Red Sandstone, and by pebbles, or angular fragments and chips of granite and mica schist being found in

the Carboniferous Limestone, near Dublin; showing that plants growing on the granite hills brought into the neighbouring sea fragments of rocks in their roots, as trees now transport such stones on to coral islands. The nature and disposition of the beds agree exactly with this hypothesis.

Depression beneath the waters of the Carboniferous sea commenced on the south-west; or else, being equal over the whole area, the old land was much lower on the south-west, and was earlier brought down beneath the waters. A great thickness of Old Red Sandstone was deposited there, consisting of fine clays and sands, without any pebbles to form conglomerates. Farther to the north and east conglomerates set in at intervals, derived from the old pebble beaches and river beds of the land in that direction. In the finer-grained beds we find the plants, and the Anodon, or fresh-water mussel, and remains of fish (Coccosteus, and others), which from their associations here we should presume to have been fresh-water fish. A fragment of the claw of a Eurypterus, or similar Crustacean, may have a similar terrestrial indication, since Professor Huxley informs me that there is nothing in Pterygotus or Eurypterus to show that they were not inhabitants of fresh water.

The depression continuing, the sea extended further and further over the northern area. In the south-west (after the formation of the Old Red) a great accumulation of fine mud, silt, and sand took place in this sea, eventually forming a thickness of 5000 or 6000 feet, many beds being crowded with marine shells and other organisms. These formed the Carboniferous Slates of Sir R. Griffith, the Devonian Beds of the West of England. In other parts of the same sea, to which these earthy deposits did not extend, or only extended occasionally and in small quantity, limestone was formed from the *débris* of marine animals, and very largely from the growth of submarine forests of Crinoids.

As the land was gradually and successively depressed, beaches and shore deposits were formed on the margin of it, and extended occasionally some few miles from the land, perhaps forming deposits of sand and gravel, of red, yellow, or other colours, at different levels in the Carboniferous Limestone. The beds of limestone resting on those sandstones, although locally the lowest beds of limestone, would yet not be the lowest beds of the formation, since further out to sea, where the sandstones died away, they would rest upon other limestones of a previous date, perhaps on several hundred feet of such beds.

Finally, from some change of circumstances, which we are left dimly to guess at, the whole sea became loaded with black mud and fine silt, and inhabited by a rather different set of animals, or rather by a selection from the previous inhabitants that had hitherto been in a minority, but whose multiplication was favoured by the new circumstances, while that of others was prevented by them. The Lower Coal-measures were thus formed. In some places these Coal-measures seem to have been themselves extended over the still sinking land, and to have deen deposited directly on the Old Silurian rocks, without the

marl." A grey clay, one or two feet thick, often lies below the shell marl, between it and the coarse limestone gravel. These substances show that the bogs spread for the most part over the sites of old shallow lakes.

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Lower Limestone Shale, black shales, with flaggy limestones in the upper part, and thin flaggy sandstones in the lower; almost always highly fossiliferous, and graduating downwards into the top of the Old Red Sandstone, ...	100 to 300 feet.

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My very first examination of this supposed Upper Limestone, in the spring of 1851, showed me that it dipped under black shaly beds, which were called Calp, or Middle Limestone, and therefore that the mere lithological characters of the beds were in that district no safe guide to their stratigraphical position.

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Trusting to the persistency of this type of subdivision, the Carboniferous Formation of the county of Dublin was originally mapped in accordance with it by Mr. Du Noyer, under Dr. Oldham; and the Index Map of the county (published before the construction of the one-inch map) showed Calp and Lower Limestone only in the northern part of the county, while a patch of Upper Limestone was introduced in the southern part of the county, about Belgard, south of Clondalkin.

My very first examination of this supposed Upper Limestone, in the spring of 1851, showed me that it dipped under black shaly beds, which were called Calp, or Middle Limestone, and therefore that the mere lithological characters of the beds were in that district no safe guide to their stratigraphical position.

It was not till the beginning of the year 1859 that I examined the northern part of the county of Dublin, immediately after seeing the Kilkenny Coal-measures, as described in a paper published in vol. viii.* of our "Journal;" and I found that large parts of the rocks, hitherto considered to be Calp, or Middle Limestone, were in reality the lower part of the Coal-measures.

Other patches of Coal-measures were subsequently mapped by Mr. Du Noyer, under my direction, in the county of Dublin, and the adjacent parts of Meath. These Coal-measures rested chiefly on dark earthy limestones, with occasional shaly beds, of the lithological character usually assigned to the Calp; and I concluded that nearly the whole of the Upper Limestone of the county of Dublin and the neighbourhood had assumed this earthy and calpy character.

No very definite thickness, however, could be assigned to this upper subdivision; and thick beds of good grey limestone were observable in some places, as in the Milverton quarries, near Skerries, at no great distance from the base of the Coal-measures; while in other places the earthy and calpy characters prevailed over much wider areas, and apparently, therefore, through a much greater thickness of beds.

The singular conglomerates of Silurian fragments and blocks found in the Carboniferous Limestone at Rush were, according to our then grouping of the rocks, placed in the Upper Limestone; while similar conglomerates on the shore, north of Lough Shinny, were, solely in consequence of the lithological character of the associated limestone, assigned to the Lower Limestone.

I yielded to this grouping of the rocks, in accordance with the suggestions of Mr. Du Noyer, who surveyed the ground, rather against my own judgment, because we were thus able to include under one tint of colour all the beds which afforded good workable limestone, fit for burning into lime, and for making good building stone.

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IV.—On the Antiquity of Man. By J. S. Moore.

[Read May 8, 1867.]

The discoveries in geology for the last half century have forced the conclusion, that the six days in the Mosaic account of the Creation were six long eons, each perhaps embracing many thousands, if not millions of years. This view is not incompatible with the Word of God, wherein it is stated "that in His sight a thousand years are as but a day," to whom (having existed from all eternity) a million of years may pass "as the click of the clock."

A frequent mode of revelation of His will to man was by visions during sleep.

Assume, therefore, that the progress of finishing the earth, from the time it was without form and void to the time of its final peopling, was revealed to Moses in *six* visions, and that his account of the Creation merely describes the state in which he saw the Earth in those six successive visions, and his history of the Hexaëmeron is perfect.

In this view, so far from his account being inconsistent with geology, it is by the testimony of the rocks so completely confirmed, that it is impossible this history could have been written by any man unless he had been inspired by the Almighty—so short, so succinct, so true, so graphic, and so minute an account of the progress and successive creation of animal life, from the time of the moving of the Spirit of God on the face of the waters, and of that sublime command, "Let there be light," up to the final act of the formation of man—unless he had been divinely instructed. That this inspiration was by vision is supported by the very wording of his description. It was evening; for darkness was upon the face of the deep; "And evening was and morning was = day one" (such is the literal translation), so that the first vision was between the evening and next morning.

It is evident that the reference of Moses to the evening and morning being one day had only reference to the time elapsing during each of his own visions, and not to a shifting measure of time, which varies according to latitude.

The fossil remains discovered by geologists in the rock completely bear out and verify the several successive creations in the order of herb, fish, reptiles, birds, beasts, cattle, and creeping things; and, lastly, of mankind.

Moses (when he described what he saw in his six visions) was unaware, that for several thousand yards beneath his feet lay a confirmation of the mighty truths he was then detailing with such conciseness and simplicity; and it is only within the present century that this evidence (graven by the finger of God in the heart of the deepest rocks) has been appreciated by man. The sequence described by Moses is perfect.

The subject of the revelation by vision having been so ably descanted on by Hugh Miller and others, any further comment thereon is unnecessary.

Unable to contradict geological facts, yet unwilling to expand the six days of the Hexaëmeron, some have argued that, as nothing is impossible with the Almighty, he might have created the rocks with the resemblance of fossil remains therein enclosed, within the period of six natural days: this course of argument is unworthy a reply. Others have contended that the earth, with all its rocks and fossils, was created before the Hexaëmeron of Moses commenced; and that the six days of creation were six natural days, of twenty-four hours each.

Mr. Greswell, in his able work of the "Three Witnesses, or the Threefold Cord," comes to the conclusion that there was an interval of indefinite extent between the first and second verse of the first chapter of Genesis, which in the scriptural account of the Creation had been passed over in silence; that on the eve of the Mosaic Hexaëmeron the earth itself was in being, revolving round the sun; that the moon was also in being, and everything going on as to this day, save that the earth was destitute of light, of life, of an atmosphere, covered with water, and shrouded in darkness; that the inspired chronology of Scripture reckons the duration of created existences as measured by time perpetually in a succession of periods or eons; that it authorizes us to infer there has been a series of such eons, greater or less in number, before the Mosaic Cosmogony; and that there will be a similar series of eons destined to go on for ever, after the Mosaic creation, when everything included in it shall have fulfilled its purpose, and consequently come to an end.

To prove that the earth in its present state was created or reconstructed at the time detailed in the Mosaic account, he shows that the mean noctidiurnal and annual time traced back from the present day under their proper Julian style—that is, the noctidiurnal from a given *feria prima;* the annual tropical, from a given mean vernal equinox; the annual sidereal, from a given conjunction of the sun with the stars Beta and Zeta Tauri; the annual anomalistic, from a given conjunction of the mean sun with the apogee of the solar orbit, and all calculated for the meridian of ancient Jerusalem, are found to meet together in one year of the era before Christ, 4004, and on the 25th of April, at midnight; and mean natural menstrual time is traced back in like manner to April 25th and May 2nd, 4004, B.C.; that all these requisites may have passed back beyond that period; but, if so, we must reckon back from thence 516,000 years, to arrive at the time when they could have been all previously setting out together; that the decursus of the present state of things, which enters into our state, known as the efflux of time, commenced with the Mosaic account of the creation, and has so continued to the present.

The argument of Mr. Greswell is to the effect, that the date of 4004 before Christ commenced at the second verse of the first chapter of Ge-

nesis—"And the world was without form and void;" that the earth had previously existed for thousands of years, during which time the world of the geologists had been gradually constructed from the earliest primitive rocks, down to the Tertiary and recent deposits; that then in six natural days the Almighty commenced anew, and restored all created existences. But will naturalists and geologists agree with this view? Do they find any such decided break, or catalysis, embracing all creation of fish, flesh, and fowl, forest trees, and vegetation, to have occurred at the termination of the Tertiary period; or do they not rather find irrefutable evidence of uninterrupted continuance of life at that period in every department of nature? There had been some formations dropping off and becoming extinct occasionally during the geological periods, as well at sea as on land; but through the whole there had been others continued, so to form an unbroken connexion from the time the Laurentian and Cambrian rocks were deposited down to the present day. Would not the "without form and void" state of the earth have been more applicable to the Azoic than the Quaternary period?

If we commence the decursus of the efflux of time immediately on the creation of Adam on the evening of the sixth day, and adopt Mr. Greswell's epoch of 516,000 years as the previous preceding period of all his several conjunctions—if we look on the sixth day of the Hexaëmeron to have embraced the Tertiary and Quaternary ages—we have an eon of sufficient duration to meet the geological requirements of the Cainozoic cycle.

If we trace back five similar epochs of 516,000 years (allowing each Mosaical day to consist of so many years), we have eons of ample length to allow of the gradual formation of all the wonders revealed to us in the records of the rocks, to satisfy geological time; but the six days were not likely of equal length.

Professor Thompson has calculated the probable age of the crust of the earth to be about ninety-eight millions of years, which must comprehend the geological history of our globe ("Phil. Mag." for 1863).

According to the Mosaic account, it was on the fourth day before the sun, and moon, and stars were seen by Moses; it may be inferred from this, that on the fourth day, the sun, moon, and *stars* were made visible to the earth, and that previously they had been obscured by clouds, fogs, and vapours.

From astronomy we learn that the stars composing the great nebula of Orion are so distant, that light, travelling at its usual velocity, would not have reached the earth from that distant point in less than sixty thousand years; and, that when we now look on that nebula, we do not see it as it is at the present day, but as it was sixty thousand years ago.*

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* According to Guillemin, rays of light from nebulæ so far distant as the 75th cluster of Messier's Catalogue must (to reach us) have left more than 700,000 years ago. See "The Heavens," by Guillemin, p. 45, 2nd Ed.

As to our sun, if we adopt the Nebular hypothesis of the compression of his atmosphere, and of his casting off the earth, and all the other planets, from time to time, as his atmosphere became more and more condensed, we have measures of time, or eons, stretching so far back into eternity as to be incomprehensible to man. When the planet Neptune was thrown off (long before the earth had existence), the atmosphere of the sun must have extended so far as Neptune—what, then, must have been the time required to have consolidated its atmosphere from the outer borders of the orbit of Neptune, through its gradual diminution and condensation, until it had cast off Uranus, Saturn, and all the other planets, and only exhausting itself when it had shot forth that brilliant sparklet Mercury!

From Professor Haughton's fourth Lecture on Geology (Appendix C.), we learn, that it required three hundred and fifty millions of years for our earth to cool from 2000° to 200° Centrigade; that the time of cooling from 212° Fahrenheit (the temperature of boiling water) to 122° F., at which organic life became possible, was one thousand and eighteen millions of years; and that it would require twelve hundred and eighty millions of years to cool from 122° to 77° F.

Who is there, on examining these inconceivable periods, would remain of opinion that the Almighty, the great Creator of all the thousands of suns we see, and of the infinite numbers which are beyond our ken—whose ways and works have been from everlasting—commenced on a Monday morning, nearly six thousand years ago, to make this earth, and finished his work upon the following Saturday night? Let the six days of Moses be treated as six long eons, extending back towards infinity, and all will be in simple harmony and grandeur—a creation becoming gradually perfect through countless ages, worthy of the great and everlasting Being we adore.

Having once viewed the Mosaic account of the creation in the light of visions, exhibiting six distinct scenes selected from six different cycles, let us again turn to the fourth Lecture of Professor Haughton on Geology, and observe his remarks on the gradual production of animals on the face of the earth, and then proceed to man.

In the 94th page he says:—"If we confine ourselves to the broad distinctions that exist among the various races of animals (and indeed we may say of plants), there is no fact more certain in the history of the globe, than that, as the world grew older, a greater variety of species were introduced upon its surface; and those species and creatures that were so introduced became higher and higher in their organization, until the Creator was pleased to crown the whole, by the introduction of man himself." The learned Professor expresses the supposition that, as the conditions of life upon the globe changed and improved, so as to render possible the existence of more highly organized groups of creatures, those creatures were placed there by the will of their Creator.

Taking a cursory glance over the various tribes of man—some in their native forest, others in their populous cities; some in their huts of

ice in the polar regions, others again under the burning sun of the torrid zone; black, white, red, copper-coloured, of every variety, all differing in intellect, in habits, in language, in the shape of the skull, in the framework of the body, length and strength of the bones, but each and all adapted to the climate in which they were respectively planted, and to the circumstances in which by nature they are surrounded—does not a strong feeling arise that they (like those of the brute creation of various degrees of organization, some higher, some lower) have been placed from time to time upon the earth, as it was prepared to receive them? We ask ourselves, can all these varieties be derived from the same pair of ancestors? Are we not at liberty to infer that there were other races of man on the face of the earth prior to and coexistent with Adam?

Mr. Page (in his "Geology for General Readers") has the following:—"In investigating the antiquity of man we are dealing with a question of natural history, and are bound by the same method of research as if we were treating of the history of the Mammoth or Mastodon. Our business as geologists is to examine the rock formations composing the earth's crust, to note their imbedded organisms, and to fix their relative antiquities. Wherever the remains of man or of his works occur, there we presume has been his presence; and, though we cannot assign any definite date to the time of such occurrence, we are, at all events, entitled (judging from all the correlative circumstances) to say that it took place 6000, 10,000, or 20,000 years ago."

It was on the sixth day that God made the beast of the earth after his kind, and cattle after their kind; and on the same day he made man, "male and female." If it can be shown that beasts and cattle existed thousands of years before Adam, that would be conclusive as to the great extent of a Mosaical day.

We have already taken the cycle of 516,000 years (for argument's sake) as the length of the sixth day of the creation.

There were ages within that time, during which the Mammalia could not have existed in the northern portion of the globe (say, within fifty degrees of the pole), on account of the intense cold of the Glacial Periods. The time and duration of these it is difficult to fix; and, though there appear to have been several of them, the latest will be sufficient for our present purpose.

The cause of these Glacial Periods has been traced to the precession of the equinoxes, and to the change in the eccentricity of the earth's orbit. These produce in the northern and southern portions of the globe a slow periodical change of warmer and colder cycles. Mr. Croll (by the aid of Leverrier's formula) has calculated the superior and inferior limits of the eccentricity for one million of years before and one million after the year 1800.

The table of the calculations before 1800 is to be found in Sir Charles Lyell's "Principles of Geology," tenth edition, p. 293.

What we gather from this is, that about two hundred and ten thousand years ago, owing to the eccentricity of its orbit, the earth

when in aphelion was about ten millions of miles more distant from the sun than when in perihelion.

It has been stated by Mr. Denison that the average winter cold of Europe was then seventy-two degrees F. lower than it is now; that then all Europe was covered with snow and ice, which the heat of summer had not time to melt, and which slid and scraped down our valleys, like the glaciers in the Alps, and as icebergs slide into the Atlantic Seas; that then winter was nearly a month longer than the summer.

This scraping down of our mountains and valleys produced the accumulations of sand, gravel, broken rocks and stones, now called the drift.

Recent searches made in the drift have disclosed (amongst others) the bones of the Rhinoceros, the Cave Bear, the Hyena, the Woolly Elephant, and, contemporary therewith, *the remains of man*, his primitive weapons, flint arrow heads, stone hatchets, and other implements.

Sir Charles Lyell states that (according to Tilesion) thousands of fossil tusks of the Mammoth have been collected in Siberia, and sold in great plenty; and that, according to his belief, the bones still left in Northern Russia must greatly exceed in number all the Elephants now living on the globe; that in the flat country near the mouth of the Yenesei, between lat. 70° and 75° N., many skeletons of Mammoths, retaining the skin and hair, have been found; that in 1805 Mr. Adams obtained the entire carcase of a Mammoth in lat. 70° north; it fell from a mass of ice, in which it had been encased on the banks of the Lena; so perfectly had the soft parts of the carcase been preserved, that the flesh as it lay was devoured by wolves and bears. He mentions other skeletons of the Mammoth which were found (one at lat. 66° 30′ north), with parts of the flesh in a perfect state; and that the bulb of the eye of one is now preserved in the Museum at Moscow; others were met at 75° 15′ north, near the River Taimyr, with the flesh decayed.

Sir Charles remarks:—"One thing is clear—that the ice, or congealed sand, in which the bodies of such quadrupeds were enveloped, has never once been melted since the day when they perished, so as to allow the free percolation of the water through the matrix; for, had this been the case, the soft parts of the animals could not have remained undecomposed."

Again, according to the same authority, Professor Von Baer, of St. Petersburgh, states that the ground is now frozen permanently to the depth of 400 feet at the town of Yukutzk, on the western bank of the Lena, in lat. 62°.

Mr. Midendorf told him, in 1846, that in his tour in Siberia, three years before, he had bored to the depth of seventy feet, and, after passing through much frozen soil mixed with ice, had come upon a solid mass of pure transparent ice, the thickness of which (after penetrating through two or three yards) they did not ascertain.

Respecting the body of the Mammoth found by Mr. Adams, and

perfect as the day on which he was imbedded in the ice, this was an animal belonging to the Ante-glacial Period, and yet created in the same Mosaical day, and contemporaneous with man.

It may be said that this animal (with others) was inwrapped in the ice after the Glacial Period. Let us consider that question.

We can conceive a period when the vast, now icebound, hills and plains of Siberia were covered with noble pine forests, and with prairies bearing a luxuriant vegetation, when Woolly Elephants, and many other animals browsed upon their shrubs and grasses, and reclined under the shade of their noble forest trees.

Again, we can follow in our mind the gradually increasing eccentricity of the orbit of the earth, until its distance from the sun (during the winter season) became so extended, that the effect of the rays of the summer's sun, feebly falling through clouds, fogs, and mist upon the gelid surface of the northern zone, hardly sufficed to enable the animals inhabiting those then icy regions to sustain their struggle for life. Winter after winter herds of them perished from the increasing intensity of cold, and became encased in snowy shrouds. At length the heat of the sun was unfelt; the whole country, so far as the fiftieth degree of north latitude, became enveloped in an icy mantle; the struggle for existence was at an end, and all animal life within that region became extinct. The Mammoth we have mentioned, when full of life and health, being suddenly entombed, would have been preserved by the intense cold in the same state of freshness as at the moment of his being frozen; and, whether the time to elapse between his incarceration and his subsequent liberation by the melting of his icy coating were one year or thousands, still his solid flesh would have undergone no change.

As to his having been shut up during the wane of the Glacial Period there are difficulties and insuperable objections. First, it is obvious that during the intensity of the Glacial Period all animal life must have been destroyed within 50° of the North Pole; that, from the extraordinary number of the fossil bones of Elephants found near the Arctic Circle, that country must at the period of their destruction have been thickly inabited by these unwieldy animals; and, from the remains of some having been found preserved in such a fresh state, many must have been in actual active life when overwhelmed in the snow so far north as the 75th degree of latitude.

Suppose any of their race had been inhabitants of a milder climate than 40° N. during the period of extreme cold, and had thus escaped destruction, it would have been impossible for them to have found their way (passing from 1000 to 1500 miles) to 70° or 75° N., and to have again replenished that part of the globe with their race, in the interval between the extreme glacial age and the time of their destruction; particularly as, even to the present time, the Glacial Period in those latitudes has not terminated, and where hoary winter still holds the earth in his chilly grasp. What would have been their inducement to forsake their genial districts, and to wander north? On what were they

to subsist whilst roaming towards the icy banks of the River Lena; and if there, what could have been their food? That country is now (and has been since the cycle of extreme cold) bare of trees, and of vegetation sufficient for their sustenance.

The Rev. Mr. Brown (in his book on the "Icy Caves of France, Switzerland," &c., p. 274), states that Von Kotzebue and his party, having encamped on a large plain in Siberia, discovered a fissure which revealed the fact that the moss and grass on the surface were a thin coating on a layer of ice, 100 feet thick; that this was not mere frozen ground, but aboriginal ice, which formed the walls of the fissure. They found the bones and teeth of the Mammoth imbedded. Those large animals could not have lived and multiplied on such slender fare as moss, nor could they have existed and found sufficient nourishment at any time in Siberia since the culmination of the Glacial Period.

Page, in his "Past and Present Life of the Globe," says—"It is all but certain that over the plains and through the forests of the old world man hunted the Irish Deer, and speared the Mammoth, just as at a later period in the same region he lassoed the wild horse, and impounded the Ibis and Buffalo."

The conclusion we must come to is, that the Mammoth was imbedded in the ice, perhaps two or three hundred thousand years ago, at the approach of, and not during the decline of the Glacial Epoch.

Hitherto Adam has been deemed the first of mankind. Taking it for granted that the Word of God cannot be contradicted by his works, we should examine the Scripture carefully, to ascertain whether Adam is so decidedly stated to have been the first created man, that all further inquiry on the subject is closed; or whether, in fact, the traditional part of the Mosaic account of the creation of man was only intended to give the history of one particular family, through which the descent of our Saviour was to be traced.

In the 27th verse of the 1st chapter of Genesis, Moses states that God created man after his own image; "male and female *created he them.*" In the 28th verse, "God blessed them, and said unto them, Be fruitful, and multiply, and replenish the earth." 29th verse, "And God said, Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree in which is the fruit of a tree yielding seed; to you it shall be for meat."

Taking it for granted that each day of the Hexaëmeron was an epoch of time, we see in the first chapter of Genesis that the Almighty had created *mankind*, male and female, had ordered them to be *fruitful and multiply*, had given them dominion over everything that moveth on the earth, and herb, and fruit for meat—*there was no restriction, nothing excepted;* and we now leave them to increase and multiply, whether the male and female then created were two or two thousand, or any indefinite number.

"And morning was and evening was" = the day six. Then comes the second chapter, the seventh day, second verse—"And on the seventh day God ended his work which he had made."

This closes the *revealed* account of the gradual progress and preparation of the earth for the reception of man, and of his creation.

The history of Adam, his being placed in the Garden, his fall, and the events which occurred from thence to the time of Moses, can only be looked upon as an account of Adam and his descendants, carried down by *tradition*.

Moses collected the traditionary fragments, and formed them into a continuous narrative.

The creation of Adam was inaugurated with great solemnity. The vast zodiacal cycle of upwards of 25,000 years had performed one of its grand revolutions—it had brought an ancient era to a close. In setting forth again from its zero point, it was met by the several kinds of time before mentioned (elaborately calculated by Mr. Greswell to have revolved to the same node after a lapse of 516,000 years). All, having thus united, were setting forth together at the vernal equinox, in the year 4004 B. C., on their several courses, and commencing the present efflux of time.

Then (according to the received authorities) was the Adam of Tradition created.

The Tradition.—Genesis, Chap. ii. v. 5.—" The Lord God had not caused it to rain upon the earth, and there was not a man to till the ground."

This has been held to prove that there was not a man then existing on the face of the earth; but, it is submitted, it only proves there was not then a man of a particular trade or occupation. Suppose the statement had been that there was not a man to build a house or navigate a ship, could any other inference be drawn from these words, than that there was not then a mason or a sailor? The pre-Adamite inhabitants were savages—supporting themselves by the indigenous fruits of the earth, by fishing and the chase; but there was no cultivation of the earth (the first approach towards civilization), and therefore there was no man to till the ground, or rather *appointed* for that purpose.

By the twenty-eighth and twenty-ninth verses of the first chapter, God had given to *mankind* dominion over fish, and fowl, and every living thing that moveth on the earth, also every herb and plant. Man was abundantly supplied with food in his early savage state. He supported himself by hunting and fishing, and by eating fruits and roots, as all early savage nations yet do; in that state there is no inclination to labour; neither had he been appointed to till the ground.

Adam appears to have been specially formed, specially cared for, and specially restricted: verse 7—" And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life, and man became a living soul."

8th verse—" And the Lord God planted a garden eastward in Eden, and there he put the man he had formed."

9th shows how God furnished the garden with every tree pleasant to the sight, and good for food.

10th to 14th.—The boundary of the garden defined, as if to shut off Adam from the outer world.

15th verse.—He put him into the garden to *dress* and *keep* it (or till it).

This was a special duty put upon Adam to cultivate the soil: he was not to lead a savage life, and wander about the world, hunting and fishing for subsistence.

16th verse.—"Of every tree of the garden thou mayest freely eat."

17th.—"But of the tree of knowledge of good and evil, thou shalt not eat of it."

To the *mankind* of revelation God gave permission to eat of *every tree:* "to you it shall be for meat;" but to Adam (the man of the tradition) he says, "Thou shalt not eat of the tree of knowledge of good and evil."

There is here a clear distinction made between mankind, "*male and female,*" as in the first chapter, and Adam as in the second chapter.

At this time Eve had not been formed; but for her there was also a special creation. This, again, appears different from the creation of mankind, "*male and female,*" mentioned in the revelation.

Chapter iv.—After Cain had killed Abel, and when his doom had been pronounced—"a fugitive and a vagabond shalt thou be *in* the earth," 14th verse—he replies, "Behold, thou hast driven me out this day *from the face of the earth,* and from thy face shall I be hid, and I shall be a fugitive and a vagabond *in* the earth; and it shall come to pass that every one that findeth me shall slay me."

This is a most remarkable expression. Had there then only been on the earth Adam, Eve, and Cain, who was there to kill him except his father and mother? Who was the *every one* he was afraid of? Does it not plainly point to other families and inhabitants then *in* the earth besides Adam and Eve? Cain also appears to draw a distinction between *the face of the earth,* where he was in communion with his Creator and with his parents, and from whence he was to be driven, and the place he calls "*in the earth,*" where he was to be a fugitive and a wanderer, hidden from the face of his Creator, and where he was apprehensive people would kill him.

15th verse.—"And the Lord said unto him, therefore, *whosoever* slayeth Cain, vengeance shall be taken on him sevenfold; and the Lord set a mark on Cain, lest any finding him should kill him. The "*whosoever* slayeth Cain," and the words, "*lest any finding him should kill him,*" must have had reference to others besides Adam and Eve.

16th verse.—"And Cain went out from the presence of the Lord, and dwelt in the Land of Nod." Does not this imply other inhabitants in other lands?

"And Cain knew his wife; and she conceived, and bare Enoch."

Where did he get his wife, if there were only Adam, Eve, and himself then living? He had no sisters. He was driven forth from the *face of the earth* a vagabond and a fugitive; he was driven from his family,

from Adam and Eve; no one accompanied him. Did he not get his wife in the Land of Nod?

"And he builded a city!" Where did he get workmen to build the city? or where did he get inhabitants for it?

20th verse.—"And Adah bare Jabal: he was the father of such as dwell in tents, and of such as *have* cattle." (This is spoken by Moses in the present tense, 744 years after the Flood.) He speaks of the descendants of Jabal as then existing, and then dwelling in tents, and having cattle.

21st verse.—"His brother's name was Jubal, the father of all such *as handle* the harp and organ." (Again he speaks of existing descendants.)

22nd verse.—"And Zillah bare Tubal-Cain, an instructor of every artificer in brass and iron."

None of these were in the ark, nor were their descendants, and yet Moses speaks of their descendants as then living.

It is now generally admitted that the Deluge was local, caused by a temporary depression of the district in which Noah resided—that Noah only described the scene of the Flood as it appeared to him. The gradual submergence of the land would not (to his eyes) have had the appearance of sinking; the waters would have appeared to come surging over the ground, and rising over the tops of the neighbouring hills, until he could see them no longer. He would have naturally transmitted to his posterity the account of (as he supposed) the submergence of the whole human race, except those with him in the ark. He was borne away by the ark to a distant land, and may never again have met with any of the antediluvians.

Abraham and Isaac may have heard the family history from the lips of Shem, who was living in their day; and thus the tradition from Adam may have reached Moses, passing through but a few people. Moses added the traditional account of Adam and his descendants to his revealed account of the creation.

If there were inhabitants on the earth who were not of Adam's race, it may be asked, why were they not mentioned by some of the Patriarchs down to the time of Moses, or by Moses himself? There is an easy answer to the question:—In those days the earth must have been partly covered with dense forests, inhabited by wild beasts; here and there were extensive plains, some thickly covered with scrub and underwood; others were rocky, barren, or sandy wastes. There were no roads or ways of transit; the march of civilization and discovery was slow. How little do we know, even at this day, when facilities for travel are so multiplied, of the centre of Africa! How little of Australia—of the heart of China, or Japan! What was our knowledge of Central America two centuries ago? Those countries may have contained many races of Pre-Adamite Man, without the probability of Moses having ever heard of them.

Supposing that many of the descendants of Adam had escaped from the Deluge—some by having previously scattered away to such a dis-

tance as to have been beyond the influence of its waters, others by having inhabited countries which did not share in the depression, and where consequently the waters of the inundation did not reach—there was but slight probability of either Moses or the Patriarchs coming in contact with them. Had they met, their oral language would have become so changed as to render them utterly unintelligible to each other. There were many chances against their meeting. We find Abraham, Isaac, and Jacob wandering over a small compass of land, with a scanty tribe, and that Egypt was the utmost extent of the travels of Israel down to nearly the time of Moses; that Moses himself, with all his journeyings of forty years, had only traversed the extent of a few hundred miles, leaving the rest of the world to him unknown. It might have contained without his knowledge numerous races of men whose ancestors had existed long prior to the creation of Adam.

Page, in a chapter on "Man's Place in the Creation in the Geological Record," after tracing him as a companion of the Woolly Elephant and Rhinoceros, and his remains mixed up with other extinct Mammalia, exclaims—"A vast antiquity! but whether ten, twelve, or twenty thousand years, we have in the mean time no mode of determining."

Again, he says (after tracing the law of progression from the lowest organisms to the highest Mammalia and to Man)—"If there be such a law of progression, Man must be as amenable to it as the rest of creation, and whatever variation occurs in his race must be taken (along with other elements) as a measure of time and duration."

Since the day that Adam was placed to till and cultivate the earth, could the civilized man have degenerated into the savage? Have we any instances of it? How seldom does the savage approach to civilization, or cultivate the ground! Every effort has been made to reclaim him from his wild and aboriginal state. In Western Australia native children were taken and educated with the children of the whites. They were as apt in learning to read and write as the children of Europeans; they were fed and clothed; but as soon as they attained the age of puberty their clothes were thrown aside, their lessons forgotten, and they betook themselves to savage life in the woods.

We collect from a paper read by Mr. Dunn, in the "Transactions of the Ethnological Society," vol. iv., that the projection of the lower jaw of the Negro is not visible at birth, and does not take place till the period of puberty; whilst in the white man the gradual increase in the jaws and facial bones is not only equalled, but exceeded by the development of the brain. The reverse takes place in the Negro: his jaws get larger and larger, while his brain remains of juvenile dimensions.

The black child is not behind the white in intelligence; but after puberty the same process takes place as in the Ape. The skull thickens, the intellectual faculty remains stationary, and the individual, as well as the race, is incapable of further progress.

It is a circumstance worthy of remark, with respect to the inhabitants of Australia, that they have no knowledge of the use of the bow and

arrow—a necessary, one would say, for those leading a savage life. Had they ever known the use of these arms, it is unlikely they would have lost the knowledge of instruments of destruction in daily use among almost all savage tribes—known extensively, and anciently used by men contemporary with extinct Mammalia (as appears from the quantities of flint arrow heads found in the drift); and yet these Australian savages had at the time of their discovery a weapon unknown to and unused by the inhabitants of any other country in the world—the boomerang. This shows a separation from and want of connexion with the other races of mankind.

Some people maintain that the Negro and all other races of Man, be their colour what it may, are descended from Adam; and that the difference of colour arises either from the effects of climate, or from some chance varieties being continued. But what are we to say to the Negro and other existing races not having changed in form, feature, or colour since they were painted or sculptured in Nineveh and Egypt nearly 4000 years ago, and shortly after the Flood! Well might the Prophet Jeremiah exclaim, "Can the Ethiopian change his skin, or the leopard his spots!" The colour of the Negro remains as he came from the hands of the Creator, unchanged and unchangeable.

Should it hereafter appear, from further researches, and the discovery of other mortal remains imbedded in such matrix as to prove beyond all question or doubt that man had existed for thousands of years before the creation of Adam, still it is submitted there would be no conflict between that fact and the description of the revealed creation of mankind, as given by Moses in the first chapter of Genesis, and that such creation may have occurred at different periods during the long protracted cycle of the sixth day.

Again, the traditional account given by Moses of the creation of Adam would not be inconsistent with the fact of many other races of man having existed on the earth, as well before, as at and after the time of Adam's appearance upon it. The world was wide enough to have contained them all, separated from the race of Adam and his posterity for ages.

Lastly, though there may have been many Pre-Adamite races, and also some of Adam's race existing on the earth at and after the time of the Flood, exclusive of Noah and his family, and not included in the ark, yet the traditional account of the Deluge handed down by Noah was to him and in his eyes strictly true. The country he dwelt in was all the world to him; the tops of the hills he was acquainted with, and accustomed to look upon, were to him the highest mountains; and when he witnessed the overwhelming of all the people that he knew of by the Flood, the waters rising until his boundary hills were covered, and himself and family floated away in the ark to some unknown and uninhabited country, what other conclusion could he have come to than that all mankind had perished, except himself and those of his household? Moses preserved the tradition, and gave it to the world as he received it, and as we have it at the present day. How far

can we be certain that the very words used by Moses have in the translation been rendered by exactly equivalent expressions?

See the vast difference between Adam and his descendants and those of the savage tribes. Adam soon discovered that he was naked, and got clad; he turned to labour, and dressed and cared his garden; his first born adopted agriculture, and was a tiller of the ground; Abel was a shepherd, and tended his flocks; Cain migrated to other lands, and built a city; Jabal dwelt in tents, and had cattle; Tubal played upon the harp and organ; Tubal-Cain worked in brass and iron; Noah builded his ark; after the Flood he was a husbandman, planted a vineyard, and made wine. That great city Babylon was founded, and the Chaldeans made astronomical observations, and had a written language little more than 100 years after the Flood.

Let us now turn to the savage races. Were the people, "male and female," whose creation is mentioned in the first chapter of Genesis, appointed to till the ground? They were not. We cannot say decidly that they were not clad—that they did not till the ground. We can only guess from the scanty information afforded by such of their relics as have as yet been discovered. These lead to the conclusion that their days were spent in the chase, and in the fabrication of their stone hatchets and hammers, of their arrow heads and knives of flint. They did not work in iron or brass, nor did they build cities. They lived and died in their Age of Stone (as have many savage nations), and as many, perhaps their descendants, are doing to this day. We find among these, nations that are wild and untameable, unhoused, unclad, without agriculture, living in the rudest state of barbarity, and unable to count even the number of their fingers. What advances in civilization have the Blackfeet Indians of North America made, or the Sioux, or Camanches, or the several other savage tribes upon that continent? What has been the progress of the Australian, and of many of the wild tribes of Africa?

There are several nations half civilized, half savage. Whence come they, or from what stock derived? Moses alludes to mixed races of man, where he points to the sons of God taking wives of the daughters of men, and their offspring becoming men of renown. They united the intellect of the Adamite with the bodily strength, and vigour, and craftiness of the savage.

There is a wide field for investigation yet before us, but we need not dread to enter into it lest our discoveries should shake our faith. The Almighty has given us in the Holy Scriptures all the information necessary for our salvation; but he has not forbidden us to search into, and investigate, and admire his wondrous works.

If we meet with what is apparently contradictory, or beyond our comprehension, we must patiently await elucidation, in the full assurance that the works of the Almighty will be found in perfect accordance with his Word.

V.—On the Post-Tertiary Geology (recent and Post-Pliocene Phenomena) of the County of Donegal, and Part of the County of Derry, and its Connexion with that of Scotland. By William Harte, C. E., County Surveyor of Donegal.

[Read June 12, 1867.]

It is, I can assure this Society, with very great distrust of my own powers, that I venture to deal with the subject of this paper, involving as it does the investigation of phenomena which have already been so ably handled by men my superiors in science, and several of whom have made this branch of geology their special study.

I have no startling theories to propound; but I have some matters of interest to describe, and it may be to correct the errors, and I conceive important ones, of some writers and men of eminence, who, perhaps carried away by the grandeur of the Glacial Period, have misinterpreted some of the physical features of these countries.

Placed in a county which for many years was almost a *terra incognita* to scientific men, it has been my good fortune to have frequently to traverse a most interesting field for observation, and Donegal, as you are aware, has already yielded much matter of scientific importance through the labours of the British Association Committee.

Indeed, after the issuing of their Report, I felt inclined to follow the advice of some older geologists, and to look upon geology, to a great extent, as "used up;" but my attention was accidentally called to the observations of some Scotch geologists; and before, indeed, I had studied their writings, I laid before you the results of notes I had taken upon the "Physical Features of the County of Donegal." The facts in that paper, as far as they go, are strictly correct—any allusion to theories in it were no theories of mine—they were simply referred to as what I conceived then to be those usually accepted.

A change of residence to the northern portion of the county, and a more intimate acquaintance with the literature of the geology of the Glacial Epoch, forced upon my attention the investigation of the phenomena to which I now beg to direct your attention.

The Post-Tertiary Geology of all countries affected by the Glacial Period has lately been paid much attention to, and the subject has amply rewarded its investigators, but still many geologists have practically overlooked it. These mere superficial accumulations of drift have been but comparatively lightly noticed.

If we are enabled to reach far back into the history of this earth, and describe the climate—the Fauna and the Flora of its early formations—it will be expected that we should be able to give a good account of those rocks now forming, and of which even we may be said to compose a part, and we should be able to describe the mighty forces in action in times so much more clearly within our reach.

Upon the subject of these accumulations in Northern Europe of the Glacial Epoch, many able men have written—Lyell, Agassiz, and

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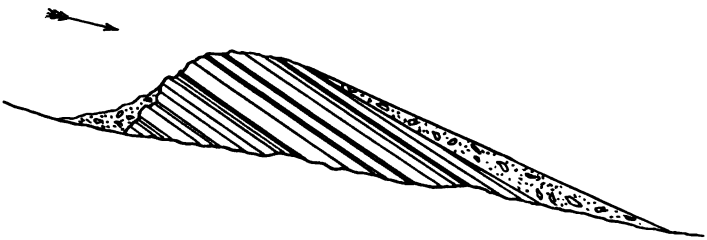

Fig. 1.—"Crag-and-tail" Rock (Tilted beds).

Fig. 2.—Roche Moutonnèe (Greenstone).

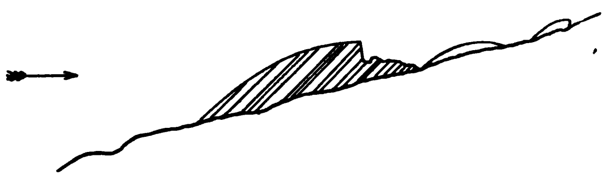

Fig. 3.—Upward Rock Shearing (dip of beds towards ice bearers).

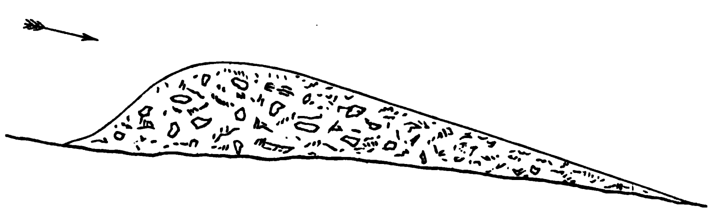

Fig 4.—"Drumlin" (Boulder-clay Ridge).

TO ILLUSTRATE MR. HARTE'S PAPER ON THE POST-TERTIARY GEOLOGY OF DONEGAL AND DERRY.

others; and more particularly, as affecting the subject before us, Professor Jamieson, Messrs. Giekie, Smith, and others.

If I venture to criticize the writings or theories of some of them, and show that some of their conclusions are untenable, it is in no unfair or carping spirit that I do so; but it is impossible to deal with the facts I am about to describe, and ignore the zeal, labour, and ability with which they have handled this subject. We have amongst ourselves some gentlemen whose patient investigations have already borne their fruits here; and, though I fear I may differ with some of them upon certain points, it would ill become me not at the outset to acknowledge the unselfish and unceasing efforts of one of them, not alone to spur me on to a task I confess I was rather lazy about, but to place at my disposal the results of his own most valuable observations and researches—I allude to the Rev. Mr. Close.

A glance at the Map is sufficient to show that there is much in the geological features of Donegal and Scotland that is common to the two countries. We have much of the same rocks, and following in the same succession; and we have both countries furrowed in pretty much the same way. I long felt that a comparison of the Geology of both would be a matter of special interest; and indeed much of this paper had been written, when, happening to glance over the admirable "Report of Portlock," upon the Geology of the county of Londonderry, and of parts of Tyrone and Fermanagh, I found, at page 51, the following:—

"Nor are these comparisons interesting only as geological speculations; they are valuable as guides to practical research; the known facts of Scotland and of Ireland mutually illustrate each other. It will, for example, be seen further on that, pursuing these analogies, new features of correspondence have been discovered in the strata of Derry and Tyrone with those of Scotland; and in like manner it may be reasonably expected that the facts ascertained and described in Ireland may lead to new researches and discoveries in Scottish Geology."

At the close of the Pliocene Period the fact becomes revealed, that the climate of these countries was commencing a great change, and becoming more northern. In the Boulder-clay we find the first record of the great change that had taken place, and of the spread of Arctic conditions over these countries; from this down to the base of the Carboniferous rocks the Geology of Donegal is one great blank; no trace whatever can be found of the intermediate formations, and I think I may fearlessly assert that fact from many independent sources of careful observation.

It is absolutely necessary, previous to discussing or describing several of the phenomena of the Glacial Period, or at least some which are attributed to it, that I should take you as rapidly as possible over the geological features of Donegal. This is necessary; for you will see how much the physical features of our latest geological records are dependent upon action occurring far back indeed in the history of this earth.

Though we have not yet reaped the benefit of the labours of the Geological Survey, we are, to a great extent, recompensed by the Geological Map of Sir R. Griffith, and the one-inch Map of Ireland.

A glance at the Geological Map will show you that, when you enter Donegal from the south, you leave behind you at the valley of the Erne the great Palæozoic formation, and you come into a country of which the primary rocks are almost (indeed, altogether, except on its margins) exclusively its components.

Commencing at the south end of Donegal, we meet a most important feature in the subject of this paper—viz., the central dividing ridge of the county, and which attains its greatest height in Bluestack Mountain, 2213 feet high; it runs nearly north and south, terminating on the mainland in the headland of the Bloody Foreland, but reappearing out at sea again as the outlier of Tory Island.

This ridge is first gneiss—the granite proper protruding through it occasionally till we come to the central granite patch, where it comes boldly to the surface, forming the Barnesmore and Bluestack Mountains. It then becomes again covered by the crystalline schists, until at Glenlehin it reappears, and forms the only rock (some greenstone dykes excepted) along that line, and on the north coast.

It expands as it goes northward; but its bold features terminate abruptly in the group of mountains, of which the beautiful scenery of Glenveagh, Glendowan, and the Poisoned Glen form such attractive features, and there the high granite ends, almost abuts against a very striking mountain (Errigle), the extremity of another range, of which more further on. Round the south ends of these Metamorphic schists creeps, as it were, a fringe of the Carboniferous and some Old Red Sandstone rocks, from the valley of the Erne. The newest rocks we have are the sandstone of the Calp Series in the Carboniferous rocks,* but they do not come higher up than the sandstones near the Barnesmore Mountains.

Now mark an important fact bearing upon our subject: this central granite ridge is as clearly and as regularly stratified throughout its entire length as almost any Metamorphic rock ever is: the beds are vertical, or very nearly so.

This main axis of elevation, as I may call it, bears nearly north and south, and across its direction those beds cut, their strike being east and west nearly.

Mind, I speak only of what I may call the granite proper, irrespective of its supposed Metamorphic character. Now, upon the flanks of this ridge lie the Metamorphic rocks, comprising all the varieties of gneiss, quartzites, mica slates, &c.; and the strike of their beds is across that of the granite, and they dip at high angles from this central ridge on both sides.

I stopped the description of this mountain range where it stops itself, near Errigle, which, however, is no part of it.

* K. C. of Sir R. Griffith's Geological Map.

Up to this point we have granitic rocks, and, if I may say it, granitic forces only (except trifling greenstone dykes), in action, affecting the position of, and constituting a system of their own, through and contemporaneous with* the superimposed Metamorphic rocks, down to near Derry, where we meet first with a trace of Tertiary formations; and where we come for the first time upon evidence of any oscillations of level, from the time of the great granite unheaval up to that of the Tertiary formations.

At Errigle commences a new state of things: its quartz rocks are thrown up to a height of 2462 feet, and they are nearly vertical, slightly dipping to the south; and this quartz range runs across to the Ennishowen mountains, rising there in Slieve Snaght to 2019 feet high; outside (north of) this range, the dip to the south increases, so that the valley or trough, in which Derry nearly lies, is on the whole a synclinal axis, though not a very regular one, being much tossed about and disturbed. This range, from Errigle to Slieve Snaght, and the outside (more northern) ranges, you will see, run parallel to the course of the greenstone, which comes to the surface in lines running more or less north-east and south-west, and is largely developed at Errigle and Muckish, and near Slieve Snaght, in Ennishowen.

An observer standing in this valley, in which Derry lies, and looking a little north of west, can see straight up to almost the foot of Muckish, the next high mountain, 2190 feet, to Errigle, and part of the same range. Behind him this valley expands across the Foyle, into the basin which is formed on the north by the remarkable basaltic outburst of Benyevenagh, and which covers the chalk, flints, and other Secondary rocks of Downhill, &c.

Now, this trap is very characteristic;† it is amygdaloidal, and it and the rocks with which it is associated have been subjected to all kinds of severe denudation.

It is quite unmistakeable wherever it is met with, and is mixed up with the chalk and flints; so that you are as certain to meet the one as the other in the shape of "drift."

Within this basin of the Foyle there are Tertiary clays on the Derry side; there are none on the Donegal side.

I am not now going to enter into the many details that I might interest you by referring to; indeed, for a paper upon Post-Tertiary Geology, I have, perhaps you will think, gone back too far; but you will perceive, by and by, the application of all this to the subject before us; the rest of the interesting geology of those early periods we may leave to our friends of the Geological Survey.

* "British Association Report," p. 49.

† The Greenstone of Ennishowen is contemporaneous with the Quartzites, which it has burst through and tossed about; but it has not affected apparently the Granite system to the west of it, beyond sending a few small dykes and thin veins into it; and in the same way the action of the Traps of Antrim and Derry lost its force, and was stopped upon reaching the primary strata to the west of them.

Donegal, as I have noticed before, nearly all consists of hills and mountains, alongside which the sea runs, and so intersects the county, that nowhere are we twelve miles from the sea; and no wonder, perhaps, that in the long ages of Palæozoic times, when our mountains were even more precipitous than at present, and far higher, that denudation to such an extent may have taken place as to sweep away the records of the missing rocks; but, at least in this respect, we are no worse off than some other countries; and on the flatter fringes which surround our coasts we might hope to find some record, at least between the Carboniferous and the Post-Pliocene periods, but we find none! Is it possible that all this time Donegal was above water?

We now come to the consideration of the Glacial Epoch. Nowhere has it been better investigated than in Scotland; and I mean to apply those investigations to this county, and, *vice versâ*, to take the liberty of applying some things I think to be learned in this county to that.

There is a great difficulty in arranging the subject. If one start with a description of the phenomena of the Glacial Epoch as you meet them, however interesting they may appear, grouping or arranging them so as to discuss any theories is out of the question.

On the other hand, if, having accumulated, as I have, voluminous notes, you seek to group and arrange them (and group and arrange them you must), you run a great risk of being led astray by some theory which carries all before it; and this, as I will show you, is just what, unfortunately, some of our geologists have done, to the great injury of a full investigation of the subject.

I will try to avoid this error, by taking for my guide certain broad facts, which have withstood the tests of most careful observers.

At the close of the Pliocene Period—whatever its cause we know not, or at least are very uncertain about—a change commenced in our climate, which from being a very warm one became more and more of a northern character, until at last an icy mantle spread over these countries. It rested all over the land, like as in Arctic regions at present; and, while its supply was kept up by the snowfall upon the higher mountain ridges, it moved off outward and downward towards the sea, and in so doing it carried with it portions of the several rocks it travelled over, grooving and scratching the surface as it went along; mixed them; rounded some; rounded, polished, and scratched others; ground down the softer kinds into mud or till, and deposited all in large masses in certain places as what we now call the Boulder-clay.

Of all this the Boulder-clay contains within itself the fullest evidence: we find in it some (a few) of the rocks of the far-off mountains, which formed the centres of dispersion; we find more and more of the nearer rocks, and, most of all, those of the immediate localities where the clay rests. In fact, the Boulder-clay, or "till," of any district, is made up of the rocks of the neighbourhood we find it in, with some of the more distant upon the line of the ice track.

Thus we have on the western shores of Donegal Bay the Boulder-clay finely developed from the "Lower Limestone" and "Yellow

Sandstone" shales of the Carboniferous rocks, and coloured blue or yellow, according to the locality they are in, and through them boulders of the limestone schists, granite, and greenstones of the district westward of the central ridge.

As we leave these places, and go into the valleys of the Metamorphic rocks, we have the same general characters preserved in their Boulder-clays, but with the grey mud of the ground, mica slate, or the yellow of the quarzites, and the usual boulders. In some places (the high grounds) it forms a covering more or less thick over the hills of uptilted rocks; in others (in the low grounds), it forms entire hills, and nearly all have a particular form, or tendency to assume it, to which I will refer again, as I think their origin has been greatly misunderstood.

The embedded boulders are often (very generally, indeed) scratched in lines, running in the direction nearly of their longest axes, and the marks of the rocks below. Except where local circumstances may alter, it is scratched and grooved in the direction before indicated.

I will not dwell upon these groovings and striations; they are to be met with everywhere almost, except where the exposed rock has been weathered out under the Boulder-clay, where it is, or under the sod where it is not, and upon the bare rocks.

There is another very important feature associated with the foregoing—the occurrence of *roches moutonnées*.

They are to be met with almost in every district, and consist of rocks ground down, rounded, smoothed, or shorn, and they afford the clearest indication of the direction *from* which the grinding agent came; the most shorn or ground portion being turned against its course, and therefore offering the greatest resistance, while the lee side, being unsupported, is frequently broken away.

But one at first sight very extraordinary feature must not be passed over here—namely, that we find the sides of the mountains or high hills in many instances shorn and striated by a force directed apparently from the base of the hill up to the top, and down the other side. It often occurs in the case of isolated hills. I believe the explanation given of this phenomenon to be a complete mistake; but I will reserve my remarks until I lay before you further on the views given of it by the Scotch geologists, as it does not affect immediately what I am now describing—viz., the line of motion of the ice sheet.

Each dominant mountain (or rather former dominant mountain) ridge in Donegal had its system of radiating ice movement. From the higher mountains in those ranges I have described the ice struck out, and passed onward and downward to the sea.

It would only be a tedious recapitulation of facts to point out the numerous localities where these different features develope themselves.

To some of them I must draw your attention by and by; but, if I might select a district for interesting investigation, I would name the north-coast of Donegal, from Malin Head to the Bloody Foreland, where the geologist will find a display of nearly all the Glacial phenomena, not exceeded, perhaps, elsewhere in these kingdoms.

In all cases I assert (if an exception attributable to local causes merely does not occur), the phenomena I have alluded to clearly indicate a downward and outward movement from the great ice bearers. This portion of the subject has been well investigated by the Rev. Mr. Close. I have not had the pleasure of seeing his papers; for we, non-resident members of the Society, do not enjoy the luxury of knowing almost anything of the papers read at one Session before another comes on—a defect, I may say *en passant*, which I hope will be remedied.

Knowing, however, the extent to which the question of striations and groovings has been investigated and written upon, I need only notice the fact of their universality.

In the Boulder-clay, fossils have been found from time to time, such as the remains of elephants, etc. I have never been able to find any, nor have I heard of their occurrence in Donegal.

Resting upon the top of this Boulder-clay, often, but never below it (so that its superposition is invariable), is found an assemblage of water-worn rocks, stones, and gravel—a coarse gravel, in fact, varying in size from sand up to large boulders: they are never scratched or striated. It is often, when low-lying, stratified in irregularly contorted and false-bedded layers. This is the so-called "Valley gravel;" its origin has been involved in some obscurity; but there can be no doubt but that it is Boulder-clay, washed out, rolled, and sifted from the higher levels—for such the composition of its pebbles shows it to be; and, as I will hereafter show, I believe it to be an entirely fresh-water deposit.

It extends far up the valleys, and flanks of mountains, to a height sometimes of 400 feet in Donegal, much higher in Scotland. Below it form eskers, kames, &c.; but one peculiar feature of this formation is, that it is almost, at least at high levels, confined to the country east of the central granite range, though we have the boulder clay upon both sides. It attains its greatest development in the valleys of Ennishowen and Kilmacrenan. It appears, but at low levels only, in the valley of the Finn, and at a few spots on the west coast.

Overlying this we have another deposit, always distinct from the former—viz., brick clays being, undoubtedly the finer clays washed out of the Boulder-clay, carried further, as they were held in suspension by the floods, and deposited in tranquil fresh water. They contain no animal organisms, and have a small admixture of fine sand and very small pebbles—the colour of the local rocks predominating.

We have next the fact of large and small Erratics scattered over the face of the country: so far as I know of them, they are always traceable to the grat centres of dispersion which I have described. I shall have more to say of them.

We had, of course, our local glaciers towards the close of the Glacial Epoch; and we have our rock basins, of which I shall have more to say.

All these phenomena we have developed in more or less perfection in Donegal, and they derive particular interest when compared with those for the same period in Scotland.

About 1838 Mr. Smith, of Jordan Hill, in Scotland, published his

interesting discoveries of the occurrence of beds of Arctic shells at high levels in Scotland. In 1863 Mr. Archibald Giekie, of the Geological Scotch Survey, published an able treatise on the "Phenomena" of the Glacial Drift of Scotland. He has been followed by Professor T. F. Jamieson, in a masterly paper, upon the "last" Geological changes in Scotland,* and we have been lately treated to another publication from Mr. Campbell, entitled "Frost and Fire," to which I will refer again.

It is, however, from the writings of Mr. Giekie and Professor Jamieson that I draw the following information as regards Scotland, except where I allude to my own investigations there :—

In Scotland the Boulder-clay is well developed, and the description I have already given answers for it; but after its formation a remarkable change took place, for the country became depressed to a depth at least of over 500 feet,† though it is only in a few localities this depression has been observed to that extent.

On the top of this Boulder-clay we find beds of finely laminated clay, sometimes as much as thirteen feet thick. This clay is always unfossiliferous; its surface is often irregular, water-worn, in fact; and filling up the hollows of, and overlying this laminated clay, there occur beds of a very different clay, being sandy in its composition, varying from a few inches to three feet thick, undoubtedly an old sea bottom.

I will not here enter into any analysis of the character of their fossils, saving that they undoubtedly form a northern group, comparatively few living south of Britain, while a very large percentage are the shells of Molluscs now living within the Arctic Circle—*Tellina calcarea* sometimes predominating so as to form by far the greater portion of the collection.

These shell clays are found on (never in) the Boulder-clay. I say, never in the Boulder-clay, because some investigators have fallen into the error of confounding deposits in hollows of the Boulder-clay, or accidental deposits of the superimposed beds which were washed into fissures, or the like, of the Boulder-clay, with the Boulder-clay itself; for late and rigid investigations have shown that, where these deposits appear to form parts of the Boulder-clay, they were only accidental intrusions; and it may be safely asserted that the Boulder-clay has afforded as yet no evidence of marine conditions.

Of course I need scarcely say, that all the Arctic shells in any glacial drift are now living, though not all living upon these coasts.

Now let us compare the state of things so far in Scotland with the facts in Donegal.

Though we have so close a resemblance in the physical features and mineralogy of the two countries as to lead to the supposition that Donegal was, as it were, a great outlier of the Scottish system, I think

* "Proc. Geol. Soc., Lond.," vol. xxi., p. 161.

† I accept the case made out for this 500 or 600 feet depression in Scotland for the sake of comparison with Donegal; but, as will be seen further on, I do not think the evidence conclusive.

I can prove that the former had long ceased to be connected—if it ever was—with the great upheavals and depressions to which Scotland was subjected.

Upon the opposite shores of Scotland we have the Boulder-clay, with the evidence of depression resting upon it, as I have described. Here we have the Boulder-clay, not alone with no evidence of depression occurring after its formation, but, I maintain, decided evidence to the contrary.

I feel I have strong, though of necessity only negative, evidence of this fact. There may be positive evidence of such a thing when it exists, but there never can be anything but negative evidence of its non-existence.

These shells do not always occur on the top of Boulder-clay in any country. They only occur on some Boulder-clay; therefore, until an impossibility was overcome—namely, that every formation of Boulder-clay in the country was cut into and examined—no positive evidence could be given that no such thing exists as marine deposits on the Boulder-clay.

I am, however, bound to show negative evidence of such a character as will entitle my assertion to claim the application of the rule (one to be used with the most suspicious vigilance in geology), that " De non apparentibus et de non existentibus eadem est ratio."

The following are the facts upon which I rely:—My own avocations are those that bring me in contact with the contents of every quarry and gravel pit in the county. I have long studied them, and never omitted an opportunity of looking at them with the object of this inquiry in view. I have visited hundreds of them—have gone to and examined the subsoil of localities favourably situated for retaining any such deposits, if depression ever took place—visited numbers of railway and road cuttings through drift at low levels. Having at my disposal the services of nine assistants, they were furnished with instructions for exploration. Localities likely to be favourable for observations were indicated; inquiries were made from resident gentry, farmers, road contractors, and others; in fact, every pains were taken to ensure careful observation, and yet, with ground as favourably situated for such deposits as Scotland affords, all produced one uniform result of the absence of any evidence whatever of the occurrence of such fossiliferous deposits through the whole length and breadth of the county of Donegal.

In some instances, of course, reports were brought to me of shells being found in certain places far above the sea level; but, when I examined them, they proved to be nothing but the loose remains of agricultural operations, occurring merely on the surface, without the slightest trace of the shell-bearing strata; or else sometimes they were travelled shells, blown from the sandhills in upon the land. Some of the localities explored were such as to leave no reasonable doubt from their position that, could any marine deposition have taken place, it would have been preserved, but nothing of the kind was found.

Portlock describes Tertiary (but not Recent) clay beds in the basin on the east side of the Foyle, but they cease when that basin meets the primary schists at Eglinton (called Muff when he wrote),* and never are found west of it; and Colby says, page 9 of "Ordnance Memoir of Derry"—"No shells, either fresh-water or marine, have been found in detritus gravel or clay of this parish," *i.e.*, Templemore,† west side of the Foyle.

This is very important to note; for here we have the Tertiary clays stopped short when they touch the primary schist southward, as well as no remains of Molluscs, recent or otherwise, when we travel westward of the Foyle basin, which is part of the Donegal system.

One case has been brought under my notice that I must not by any means pass over. Portlock, in his "Report on the Geology of the County of Londonderry, and Parts of Tyrone and Fermanagh," extracts, at page 81, the following from the MS. Journal of Bishop Nicolson:—

"March 17th, 1718 (St. Patrick's Day), the King was pleased to nominate me to the Bishoprick of Londonderry. . . . . June 21st.—Going through ye Ld Mountjoy's Woods, and by his demolishd house at Newtownsteward, we were met by Dr. Hamilton, &c., &c. N. B.—We passd over ye River at Lifford, the County Town of Donegal; as Omagh. In coming down to the bridge, I observed ye stones full of a lustre-like antimony.—Qu., If lead may not be had here?"

"July 5th.—N. B. The Mountain of Sleaver Snaght (*i. e.* Snowdon) is the highest in Inchowen: on the top whereof, saies Mr. McManus, there were beds of shells (of oysters, cockles, and mussels), whch have laid there since Noah's flood, and have alwaies a moisture on 'em at high water."

To this wonderful story the worthy Bishop puts a "Qu." This entry was made on the 5th of July, but on August the 5th he comes out with the astonishing entry—"Oysters on several mountains." After this he visits the Giant's Causeway, which he says is "Plainly a range of extraordinary columns of stone, tumbled headlong into ye sea from ye neighbouring rocks, which are visibly of ye like strata of multangular pillars, pentagons, hexagons, &c."

Portlock says, that Bishop Nicolson was known and esteemed as a man of science before his removal to Ireland; and it appears (Portlock, page 23) that he designed to write the natural history of his diocese, and requested his clergy to make collections in their respective parishes. Many complied, particularly the Rector of Magilligan. We are, unfortunately, left little information as to the extent or contents of the Bishop's collection.

The Bishop was a man whose writings were, for the period at which he

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* There were two "Muffs"—one in Derry (now "Eglinton"), and one opposite it, in Donegal.

† Templemore is 12,611 acres in area, and forms part only of a locality adapted for the preservation of Tertiary or other beds as well as the opposite side of the Foyle.

wrote, entitled to respect; and, however absurd the statement as to these shell beds may appear to any one who has explored Donegal, it being placed on record (and it is the only instance recorded), I felt bound to investigate it thoroughly.

First of all, the idea of "beds" of shells on the top of a mountain which is "crag-rounded"—on which, except in the hollows of the rock, the lowest vegetation struggles for existence—is out of the question. Again, the localities at the base of the mountain nearer the sea are favourable for retaining any such deposits, if they ever existed; but, like the rest of Donegal, the whole district is quite destitute of them.

Slieve Snaght (or, as we may translate it, freely) the Snow-covered Mountain, is 2019 feet high. It (or the range of which it is part) was itself the great ice bearer of the district, from which outward and downward the ice poured; and, if there had been any deposits of shells, such is its form that even a sub-Arctic climate in later times must have swept them away.

Ostrea edulis is, however, not found fossil amongst Arctic shell beds. It is Post-Glacial, could not live, in fact, in the sandy deposits where the Arctic shells are found. Its habitat is in the estuarine mud of our shores, and the idea of such having been on the top of Slieve Snaght is simply preposterous.

But in all times the tendency to relate the marvellous to strangers, like the Bishop, taking notes, is very great. This I know myself, for I have got many a "sell."

There may have been, and probably was, a grain of truth in this story. Some shells may have got there by the many accidents that do occur.

At the foot of this mountain was a fine oyster fishery—indeed, several of them all round it, but particularly at Strabreaghy Bay, and at Inch, near it. Now, in my paper on the "Kjökkenmöddings" of the county of Donegal, I pointed out the habit of the mountaineers, who come down at certain times, and feed upon and carry away with them the shell fish of the coast; and indeed a considerable trade is driven by supplying this article of food to the country people.

You see the Bishop enumerates only edible Molluscs—viz., "Oysters," "cockles," and "mussels."

Now, Slieve Snaght commands a magnificent view of the whole country, sea, loughs, &c., of the North of Donegal. It is easy of ascent, and is just the place where the early inhabitants would go to watch and mark down their game, deer, &c., in which these countries abounded, and carry with them the delicious food nature so plentifully bestowed upon them below; "Herds" would do the same thing in later times; so that you see there was nothing extraordinary, at least as a fact in natural history, as to the occurrence of shells alone there. But here comes the cream of the joke. Mr. Mc Manus was evidently a wag; for, finding the Bishop booked the story with the same ease as he would swallow the oysters, he adds the little tale about the "moisture" on the mountain top. Here my personal experience comes boldly to the support of the

historian; for I can assure you that, high water or low water, these delicious oysters possess the highest affinity for that same Innishowen's "native" "dew," that has rendered it famous now and for ever! And, to the good taste of the inhabitants be it spoken, I never knew them to consume the oysters without adding a little of that same "*moisture!*"

Excuse my little expansion of this subject; but you know it is not often one catches so rich a treat as a real Bishop booking geological notes in Donegal!! "O tempora! O mores!"

Having now examined the question of the relative Geology of Donegal and Scotland, so far, and established the point that, while a depression took place in Scotland after the boulder clay, as evidenced by the shell-bearing beds of the Clyde, &c., none such took place in Donegal, we come to the next feature of the period—namely, that of the Valley gravels. This formation, though by no means so striking at first sight, is, I believe, the result of the most important period of the Glacial Epoch, and into which, contrary to the practice of more eminent geologists than I am, I venture to transfer some of the phenomena attributed to the earlier glacial action. These so-called valley gravels are, to a great extent, or at least have been heretofore, surrounded with many difficulties as to their origin. Some think them to be a fresh-water formation; others, partly fresh-water, and partly marine. My own opinion differs somewhat from both.

It is, I think, fairly established that they are unfossiliferous. In Scotland they are so; and in Donegal, if patient investigation can prove anything, I assert they are so too.

One point at least is placed beyond all dispute, that they mark a decided and important feature—namely, a change in the previous conditions of the country—a change, at least, towards the breaking up of the Glacial Period.

And recollect that any change, even in a small degree, towards such an end, must have been a great one. Let it be only a short step, if you will; checked perhaps from time to time by renewed severe glacial action, the climate oscillating between an Arctic and a Temperate one, it may be, and very likely was; but, even so, any change then means the letting loose of gigantic forces. It means all the opposites of nature's powers being brought into collision; it means the crushing and scattering of disrupted ice continents—rocks, bound up heretofore in the ice mantle, torn from their places by the increased power of alternating frosts; new rivers starting into life; old ones increased in volume; great and varied atmospheric changes; great heat, great cold, floods and storms beyond what our ideas can picture meeting on the coasts, tossing about tremendous icebergs; denudation going on with a rapidity and power we can have no idea of, nor need we attempt by the liveliest use of our imaginations to realize. It is here, then, that I place some of the grandest phenomena of the period.

Before this the ice sheet that covered the country was, to a very considerable extent, conservative in its action, except on the outskirts and

surface of the land. I cannot believe it did (and I think will show that it did not) "gouge out" the rock basins, or cut down the solid hills of rocks, and the soft ones of boulder clay or gravel, into the form known as "crag and tail;" neither did it "shear" the inner rock faces, as it is supposed to have done; but, as soon as the break up of that ice sheet came, then indeed were established forces of denudation such as perhaps were never exceeded on this earth before.

We must, then, examine these valley gravels a little. I have already described them as consisting of beds of rolled stones of all sizes, from some feet in diameter down to mere pebbles and fine sand; not striated.

At the lower levels they are stratified irregularly, the beds running often in cross and curved directions. Higher up this is not observable beyond what is common to river beds. Their development seems to me to bear some proportion to the height of the mountains and the quantity of the boulder clay of the districts where they occur. In Scotland they are found up to great heights, but in Donegal I have only found them up to 400 feet. They are always above (relatively to) the Boulder-clay, and out of which, in short, they have been washed.

The Boulder-clay was deposited, as I have stated, in the valleys, by the grinding force of the land ice pushing outward and downward from the high mountains. Against that course or direction of the ice motion, as I have shown you, the rocks were tilted up; between the outcropping edges the Boulder-clay must have been caught, choking up the older valleys along those edges through which the ancient drainage of the country flowed, and the effect of this old glaciation must have been to level and fill up the irregularities of the surface that previously existed, and so long as this stage of the glaciation lasted, to conserve the inner or opposing edges of the rocks, while the outside was glaciated in various ways. Consequently there was formed a more or less regular inclined plane from the high mountains to the sea in some places, upon either side of the central ridge; and so it would remain as long as this stage of the Glacial Period existed; but when the change came—the first of the thaw—the drainage must have run down the inclined plane, and of course across the old lines of the valleys, which were, as I have said, along the outcrop of the rocks, and thus took place the first step towards the ridging of the Boulder-clay.* The stuff washed out was deposited lower down: the coarser gravel, with the larger boulders through it, was dropped on the top of the lower Boulder-clay, the finer gravel carried further, the mud further still—in fact, the original deposit would be sifted. And all those deposits would be found in the valley below, the ridging pointing towards the mountains.

After a while, when the change in these conditions had proceeded so far as to clear the country of the great body of ice, the old river courses and valleys along the outcropping edges of the rocks, which I have said became choked with the Boulder-clay, would resume their former functions in a very short time; and thus we would have

* This process of ridging may be seen in progress upon a strand any day.

formed that peculiar structure termed crag and tail, which some authors attribute to the old glaciation, because those hills point up against the high mountains, from whence the great ice moved; and, judging by the uniformity of their direction, they think that their forms are due to the same cause which planed down the solid rocks into *roches moutonnées.* But a solid body of heavy ice, moving over a yielding body of soft mud, never would have given this form (Fig. 4) in a valley where it had room to expand, but would have broken it up, and pushed it before it. All this is very observable in the country between the central ridge and Derry. The old valley of the Finn, for instance, was eroded along the softer beds of mica slate, and more or less parallel to the granite range. The river, flowing eastward through these highly micaceous beds, was stopped by the harder gneiss near Stranorlar, where it turned off at nearly right angles to its former course.

I would recommend this consideration of the phenomenon of crag and tail to future investigators; for, although undoubtedly the surface of a rock crag and tail would be ground in the direction going down the tail, after a close and most extensive investigation of numerous instances, I always found, with scarcely an exception, that the tilting up of the rocks was the cause of the grinding action down the tail, and not that the form was given wholly by the denuding agent. Compare Figs. 1, 2, 3; for instance, the form of a *roche moutonnée* with the case of a rock crag and tail in the same locality: if they were both ground down into their respective forms by an agent coming from the same direction, we should find both forms assimilated; whereas directly the contrary is the case, as you may see from the diagram.

Now I have spoken of the deposition of the Boulder-clay and valley gravels. The larger masses of Boulder-clay are, and must necessarily be, at the bottom of the valleys, and those lower hills of Boulder-clay are frequently capped with the second deposit, or Valley gravel, washed down upon them out of the higher Boulder-clays at the time of the change; and I think we may distinguish two kinds of Boulder-clay, or till—namely, the original deposit under the ice, and at higher levels the ordinary drift, out of which the rounded valley gravel was washed down; it is much disturbed, and mixed with local subangular rock fragments. We have fine instances of this lower Boulder-clay capped with valley gravel in the cuttings of the Lough Swilly Railway near Inch.

These Boulder-clay and gravel ridges sometimes lose their uniformity of direction and form: they become crosscut, as it were, and much confused; and in the investigation as to the cause of this I think I have established one fact—that, subsequently to the first formation of the valley gravel, a current, which it is of some importance to trace, swept from the north-west eastwards across Donegal into the county of Derry.

I should say across the east of Donegal, because it is quite clear that no such current swept across the western portion it, as there are no cross valleys there;* and in the valleys of Donegal and Inver Bay the Boul-

* These valleys were clearly caused by igneous action, and are transverse to the general furrowing of the country.

der-clay ridges all point steadily against the higher mountain or hill ranges that surround the bay, the outward and downward motion there being beautifully defined by the mineralogical characters of the drift, as these ridges point to the granite, gneiss, and slates, &c., of the high ranges I have described. Upon this side of Donegal there is little, if any valley gravel, the Boulder-clay itself filling the margin between the mountain and the sea.

You will perceive that a little below Derry the Foyle expands, forming a wide basin, extending a considerable distance into the county of Derry, where it is bounded by high hills. By basin I do not mean alone that portion over which the water now flows, but also the low land extending from the water edge in towards Newtownlimavady, Dungiven, and round by the base of the high ground to Derry. The outlet of this basin lies between the hills of Greencastle, on the Donegal side, and the basaltic clifts of Benyevenagh; but it is perfectly clear that subsequently to the upheaval of the chalk rocks, with which this basaltic outburst was contemporaneous, the mouth of the passage of the Foyle has been greatly widened, most probably since the time of the deposition of the Tertiary clays, which are found within the basin I have been describing; but there can be no doubt but that the upheaval of these clays was the last, at least sensible oscillation of level within this basin, or we must have found some deposit of Recent shells, as well as those of the Tertiary clays, within it.

Now, if an observer stations himself on the eastern side of this basin, so as to command a view up the Pennyburn valley, a little north of Derry, and through which the Lough Swilly and Buncrana Railway runs, he will see that it opens right up to nearly the base of Muckish Mountain, a distance of about forty-five miles. Along the whole course of this there swept a current at the time I speak of, into the county of Derry. There was, of course, an enormous pile of ice upon the high mountains, which are grouped together, as I have before described, where the high granite range stops, near Glenveagh, and meets the high quartz mountains at Errigle, Muckish, &c. Descending from those mountains along this valley, we have first the Boulder-clay ridging, and the so-called crag and tail hills well developed. As we get across, passing Inch, we find the coarse valley gravel capping the lower Boulder-clay; and as we travel onwards the small hills become all valley gravel; but getting smaller and smaller in the size of the pebbles, until it at last becomes very fine gravel on the sides of the Foyle; but all through the composition of the gravel is that of the rocks through which this current passed—the granite, &c., from the very head of the valley being carried out the whole way, but getting rarer towards the end, those of the intermediate rocks being more plentiful.

Some time after I made my first observations upon these facts, I met with Portlock's "Tables of the Detritus of Derry," and was pleased to find them corroborated by the careful researches which he, acting quite independently of the glacial theories of the present day, has placed on record. It is greatly to be regretted that he had not the opportunity

of pushing his investigations into the county of Donegal; but he gives it as his decided opinion (page 631) that the current of the detritus had set in from west to east: he instances pebbles of Donegal rocks as proof of it, and in one striking instance of a "petro-silicious porphyry" occurring frequently in the Derry detritus, he is obliged to have recourse to Crohan Hill, near Lifford, for its origin, evidently not being aware that it occurs at Fahan, near the Island of Inch, and is carried eastward all along through the gravel. I have myself traced it to near Newtownlimavady. Those gravel hills point up and down the valley from Inch Island to Derry; but they spread out as they approach this basin of the Foyle, and extend down as far as Muff, on the county of Donegal side.

You will perceive that this valley which I have been describing expands a good deal round about Inch and Ramelton; to the north of it lies the range of Knockalla Mountains upon the west of the Lough Swilly, and Mamore Mountains on the east of the Lough Swilly. In fact, they are the same range through which Lough Swilly has been cut from Knockalla battery to Dunree battery. They are quartz rocks, very fissile, and have been subjected to enormous glacial denudation: the groovings and striations show this; and there can be no doubt, from an examination of the locality, that the headlands on either side of the Lough came much further out than they do at present. This range was a most important ice bearer, and from it to the sea the ice sheet moved out, leaving the most remarkable development of glacial phenomena, to which I have already slightly alluded, but will have to call your attention to some of its most striking features again. There can be no doubt, therefore, that in the time of what Mr. Geikie terms the "Old glaciation" of the country, the Lough, as also the mouth of Lough Foyle, was closed completely by the ice at this range. When, therefore, the change came, the thaw, in fact, the whole catchment basin of the Swilly, and of the valley running up to Muckish, had no other outlet than that through the valley north of Derry, and through which the enormous volumes of water and half-melted ice and sludge were precipitated into the basin of the Foyle.*

The lower formations of the valley gravels present those appearances of stratification, false bedding, and contorted strata which characterize the deposition of materials transported by rivers where they meet the sea, and therefore it has been thought by some that those valley gravels indicate both marine and fresh-water action. But no marine or other animal organisms have been heretofore found in these gravels at all; and there is no reason in my mind whatever, but quite the contrary, why they should not be found, had the sea played any part in their formation.

My solution of the difficulty is this—that, instead of the rivers or floods being precipitated into salt water, they were carried into great accumula-

* There very likely was a circular or eddy current round the basin. Drift of chalk and flints, &c., from a bed to which it is clearly traceable at Ballyrena, has been carried across, and dropped at about 30 feet above the sea, near the lighthouse beyond Greencastle.

tions or loughs of fresh water, formed by these floods, and which in such a temperature, I believe I am right in saying, would be most inimical to the existence of any animal life, either fresh-water or marine. These loughs, agitated by the violent atmospheric disturbance which then existed, would act all the part which the sea does for ordinary rivers.

On the margins of the Foyle basin, at Ture, Newtownlimavady, and a few other similar situations, we find "brick clays." They are destitute of lamination, shells, or other fossils; they have some fine sand and very small pebbles disseminated through them, and are clearly the result of the same currents which washed out the valley gravels from the Boulder-clay, but which, holding this finer matter in suspension, deposited them as mud where the force of the current had subsided; and there can be no doubt that they must be fresh-watèr, and not marine deposits, as I think it next to impossible that such a deposition could take place under the sea without preserving marine organisms of some kind.

While I was observing the foregoing facts, a paper was read by Professor Jamieson, before the Geological Society, "On the Glacial Phenomena of Caithness," wherein he distinctly traces the passage of a similar current from north-west to south-east across Caithness, which current was subsequent to the deposition of the original drift, which was, therefore, redrifted in that direction. Not having visited the locality, I am unable to offer an opinion upon the facts, or as to how far they coincide with what I have just related of Donegal. The absence of fossils in the drift of Donegal is another difficulty in the way of the comparison; but the curious circumstance is to be noted, that he has traced the drift of Caithness across the sea into Aberdeenshire.

You have seen how the glacial phenomena of Donegal and Scotland coincide, so far as the boulder clay, which required no depression of the land for its development; and you have seen in Donegal the absence of the Arctic shell beds, which are so prevalent in Scotland; and you find in Donegal the valley gravel formation, which requires no depression of the land for its formation, same as you find it in Scotland. We will now proceed with the comparison.

In Scotland, over these valley gravels occurs another interesting feature—viz., a bed of peat, extensive in some places, and which became submerged, and was again raised above the level of the sea. It contains the remains of trees and plants, now indigenous—birch, hazel, and oak are most common. And here we seem to have returned to a climate favourable for the development of vegetable growth.

I know of no equivalent to this formation in Donegal; I know of no instance of bog once submerged ever having been brought above the reach of the tide again. True, we have numbers of so-called submerged bogs and forests; but I have already stated my opinion that they do not afford satisfactory evidence of alteration of level of the coast.* Once a bog

* "Notes on Physical Features of the County of Donegal" ("Journal of the Royal Geological Society of Ireland," vol. i., p. 25).

has been submerged, its whole mass becomes permeated with fine particles of sand, &c., carried by filtration through it, and I have examined several old bogs, just quite close above the level of the submerged ones, and found no such indications; at all events, our submerged bogs do not correspond with this layer of peat I speak of; for it was depressed considerably below the level of the sea, and over it were deposited extensive masses of estuarine mud or silt. They are called Carses in Scotland, and are productive of most interesting fossils—Mollusca; but they are no longer, like the former shell beds, distinctly Arctic in their character; but, on the contrary, are of a more southern inclination even than those of the present day. This Carse clay attains even a depth of from seventy to ninety feet. Entire skeletons of the whale have been found in it; canoes, celts, &c., have been found in this silt of the Clyde; and over it we find the ordinary extinct forests and old bogs of the country, the same as we find in Donegal.

We have our estuarine mud in Donegal, but it is still within reach of the tideway in all cases: so that you see equivalents for periods of depression or oscillations of level are absent in Donegal all through the whole series of glacial beds, while all the other phenomena are common to both; and yet there are many places in Donegal which could not have failed to have preserved recent shell beds, had they been formed at high levels. I think, therefore, I have established the fact, that Donegal was stationary in Post-Tertiary times, and that therefore we must correct Sir Charles Lyell's Map of Ireland,* where he shows that only a few points of mountain tops were above water during these periods of glacial depression. That much of Ireland may have been submerged the same as in Scotland there can be no doubt, and the facts quoted by Professor Jukes, in his "Manual," (p. 675), go to prove it, though the fragmentary character of the high-level fossils renders their origin doubtful.

Having shown you what took place in Donegal, and what in Scotland, I now proceed to show you what I believe took place in neither, though men much more eminent than I can ever hope to be have written much to prove otherwise. I am not obstinately attached to my own views—indeed, I feel the responsibility of criticizing their works; and I lay my views before you, as the proper course for discussing them, believing them to be upon the side of the probable, as opposed to the impossible. It is comparatively easy to state the result of one's own observations, but it becomes quite another thing when one has to throw doubt upon the writings of men possessing more experience than I have, and who have possessed a far greater opportunity of observation; but I would not be doing my duty faithfully as an observer if I did not object, and show the grounds of my objections to what I believe to be most misleading in their records of this Glacial Period.

You will probably have remarked that, in going through the series of development of glacial phenomena, I have abstained from pointing to

* "Antiquity of Man," pp. 276-8.

some of them, as I thought it better to reserve those portions of my subject which consisted of a description of the theories put forward to account for some very extraordinary phenomena for a separate chapter by itself.

You are doubtless aware that many theories, and many plausible ones, have been put forward from time to time as regards the Glacial Epoch, its cause and its effects.

With the cause I have nothing to do: it is a subject full of interest, and quite open; but it behoves all geologists to begin with effects, and to scrutinize them carefully—to look to local circumstances, and plain and obvious operations of nature, and the ordinary results of mechanical forces, before flying to startling theories to account for what may appear most puzzling, no doubt; but I think I will show you that much that has been written has not been so with the caution that was required, while more of it deserves the name of absurdity, rather than that of sound scientific reasoning.

That a large part at least of Scotland (and the central part of Ireland, *perhaps*) has been submerged is evidenced, as far as they go, by the occurrence of Arctic shell beds to somewhere about 600 feet, unless indeed we can find that the high level shells are not *in situ*; but this must not be confounded for a moment with the old theory, that the whole country was submerged to the depth of at least 3500 feet. This is necessary to suit the theory of those who would account for the glaciation of the country—the rock furrows, and striations, the elevated erratics, &c., &c.—by the supposition of the country having been depressed, and having been subjected to the grinding action of floating icebergs dropping their loads over the then sea bottom. That theory even yet lingers in the mind of some of the land ice men, who cannot account otherwise for the fact that mountains of great height have their tops shorn by forces pressing over them from particular directions, while round and about them are the strongest evidences of what can no longer be disputed as the result of land ice moving downward and outward from the great natural watersheds of the country, the same as exists at present in Arctic regions. I must confess, with many more learned men, that, no matter what my first impressions were, I see less even than they do of any evidence of such submergence.

It becomes necessary for me to call your attention to a work published in 1865, entitled "Frost and Fire." I regret I have to do so at some length; and my excuse for so doing is, that a considerable portion of it is devoted to the subject now under consideration—that is to say, to the investigation of glacial phenomena in Ireland, and especially in Donegal—indeed, in the very localities where my researches have been carried on.

The work is decidedly a sensational one, and has attracted a great deal of notice—so much so, indeed, that before not alone were its theories properly considered, or, what is more important still, before the occurrence of its alleged facts was tested, it was brought under the notice of the scientific world in a very remarkable manner by one eminent geologist

in his Presidential Address to the Royal Geographical Society, and also by another in a late Presidential Address to the Royal Geological Society of London.

In the face of such high encomiums from these eminent geological authorities, it seems something like heresy to impugn, as I do, the whole length and breadth of the subject treated by the author of "Frost and Fire"—his facts, and of course, therefore, the theories based upon them, so far as that portion of Ireland of which I write is concerned. I am only the advocate for Donegal; outside it I can only hand over the author of this work to the treatment of the Rev. Mr. Close, or some other person competent to deal with the phenomena in Galway and the rest of Ireland set forth in this work, but which are so much akin to those described in the county of Donegal, that if I can show you, as I think I will, that the case made by the author there completely breaks down, there is little necessity for following up his investigations elsewhere. I am not to be understood as denying to the author of "Frost and Fire" the credit due for the possession of the intelligence, talent, zeal, and considerable scientific information which he has brought to bear upon the subject of his book in a manner so "quaint" as to have attracted the attention it has, and can only regret that all this was not applied in a manner which was consistent with the facts. This Society is the proper place to correct errors affecting the Geology of Ireland; and it was quite impossible for me to treat the subject now under consideration, and pass by unnoticed the extraordinary, though not unaccountable misstatements of Irish Geology in "Frost and Fire."

The author of "Frost and Fire," having assumed a theory, starts in search of concurrent facts, and of course finds them, as I need not tell you so often happens with theorists starting with a foregone conclusion. First, as to his theory; he supposes a number of ice floats projected from within the Arctic Circle southwards, when, being influenced by centrifugal and other forces, he makes them assume definite curves.

These curves, passing along from north to south and west, ought to leave grooves and other ice marks in the rocks over which they passed—always provided, as he supposes, these countries to have been at the time submerged. So much for his theory, which, I am bound to observe, is so clothed with that quaintness which has delighted his admirers, that I must be pardoned if I am unable to lay it before you in so very simple and attractive a form.

Now for his facts:—Having found some marks at the extremity of one of these curves, he follows up what he calls the "spoor," with an industry that would do credit to a better cause. As he goes along the trail of this curve, he sees everything that falls in with the preconceived theory, but, with a strange fatality, nothing that is opposed to it.

Two of those curves pass southwards through Donegal:—one he

calls the "Westport curve;" the other the "Derryveagh curve." The Westport curve (vol. ii., p. 53) he traces from Westport, in Mayo, in sundry places, until he arrives on the ground between Strabane and Letterkenny; and I will give you a fair specimen of his general observations, and of his arguments, by one of his most brilliant hits here.

At the summit level of the post road from Strabane to Letterkenny (mark, he is working up against the ice stream northwards), at a height of about 400 feet, he meets a quantity of boulders and "granites of various sorts, grey and white, quartz rock, and traps of various colours." "These travelled far (he says), some perhaps from the Giant's Causeway," and the granite is like Aberdeen; and he says, "according to theory, they [the granites] may have come thence [Aberdeen], but there is granite close at hand in Donegal."

You see that "according to theory" is the rule of observation; for, if he had examined the texture and composition of the "granite close at hand," he would have seen it corresponded, as does the line of his curve, with the granite of the central ridge, and the outward and downward motion of the ice from it. But that would have brought the granite against the stream, and therefore he flies to Aberdeen for its source!

But it is the traps which explode any such idea. You see this curve passes north over the Secondary rocks and traps of the north coast of Derry or Antrim; and, if any trap rocks had come from the Giant's Causeway or Derry, there would be no "perhaps" or uncertainty about them.

Those traps are unmistakeable in their composition; and I think I may ask my friends of the British Association Committee if there is any difficulty in distinguishing between the traps of the Giant's Causeway, or, nearer still, of Benyevenagh, &c., on the coast of Derry, and those of the county of Donegal?

The Derry and Antrim traps are most characteristic; they are amygdaloidal, vesicular, and full of zeolites, and many peculiar minerals. Now, if the granites came from Aberdeen, and brought with them trap from the Giant's Causeway, or any of the drift, which the author of this work can only see as coming from the north down along his curve, that drift must have been composed of some of those peculiar traps, as well as the white limestone and flints which are so abundant in the chalk rocks, with which these Antrim and Derry traps are associated so intimately, but of which the "dams of boulders," "gravel pits," "beds of clay" of the locality, which he mentions as forming the drift there, do not contain one trace, and which, if any current had come from the north, must have been found in considerable quantities there; but, with an extraordinary blindness to the facts, he does not see that this drift is the ordinary Boulder-clay drift, and the traps the ordinary syenite, and greenstone erratics of Donegal, swept right against the direction of his theoretic curve.

Now for another curve. To the westward of this "Westport curve"

he finds another, called the "Derryveagh curve." The mountain of Errigle lies on this curve; at, he says, 2450 feet above the sea level, he thinks he finds rock scorings, but they are uncertain; but about 1000 feet lower down, at 1500 feet, on a col he finds grooves from south-east to north-west, as he thinks, the mark of his ice stream, but overlooks the fact that they answer for the outward and downward motion as well. On this col he finds several large rounded boulders of granite, contrasting strangely with the quartz on which they lie. Now, this col is dominated by the granite mountains of Dooish, &c., from which they came, and indeed had not far to come; and they are clearly traceable in a continuous stream coming from Dooish to this col, and to the other cols, the Gap of Muckish, &c., moving right in the very opposite direction from which his ice stream comes; but we have the solution of the whole thing in the next few lines—for, lo! a little further on the cause of it all is discovered, for he finds some grooves (outward and downward motion), pointing at the mouth of the Caledonian Canal! Aberdeen Granite, again, evidently intended by the hint, while the very mountain upon which he was standing, with Muckish, &c., is surrounded upon two sides with the granite which gave out those erratics, within rifle shot; and, as I said, streaming right against, not from, this wonderful Caledonian Canal, which thus early in the world's history commenced the traffic of importing Aberdeen granite to Donegal, which certainly was sending coals to Newcastle!

After the specimens I have given, it would be trifling with you to take you through all the many supposed facts, which are all of the same kind, and which he alleges in proof of his favourite theory; but I can only say, after careful consideration of them, that they all break down upon investigation; that there is not one of them that, rightly understood and examined with reference to the local circumstances that surround them, bears out the idea of submergence; that does not conform to the universal outward and downward motion which I have described, and which is more strongly confirmed by the unerring guide of numerous "rock shearings," and *roches moutonnées* (or "tors," as he prefers to call them), with which the district abounds in the finest examples, bearing testimony, without exception, to the fact that the grinding agent moved from the mountains out to the sea in directly the opposite course to that from which he asserts it came! The overlooking of these phenomena (which are conclusive, while mere groovings are not—for grooves give the direction, but not the source of the agent)—by any one proposing to write the Geology of the Glacial Period here, is wholly inexplicable to me in any other way than by the infatuation that seizes all who, having formed a favourite theory, start off upon a tour of field observation to find facts to support it, and which, of course, they find, but do not see anything else. I demand, therefore, that these Westport and Derryveagh curves, and all belonging to them, be expunged from the literature of the Geology of Donegal.

I now turn to the work of a most careful observer and sound reasoner, and few men have written with more talent upon this subject.

In a paper by Professor Jamieson, on the "Latest Geological Changes in Scotland,"* he says, at page 166:—

"It was, therefore, not in the form of narrow glaciers, like those of the Alps, that the ice existed at this time, but as a thick cake, like that of North Greenland, enveloping both hill and dale, and flowing off, not so much on account of the inclination of the bed upon which it rested as owing to the internal pressure exerted by the immense accumulation of snow over the whole interior of the island, somewhat in the way that a heap of grain flows off when poured down on the floor of a granary. The floor is flat, and therefore does not conduct the grain in any direction; the outward motion is due to the pressure of the particles of grain on one another; and, giving a floor of infinite extension, and a pile of grain of sufficient amount, the mass would move outwards to any distance, and with a very slight pitch or slope it would slide forward along the incline.

"The want of much inclination in the surface of a country, and the absence of great alpine heights, are therefore objections of no moment to the movement of land ice, *provided we have snow enough.*"

"Now, let us look the matter fairly in the face." . . .

I do not know that we are justified in granting unlimited snow—in the highest known Arctic latitudes the mountain peaks protrude through the snow covering—but we may grant it, for the sake of the argument. Professor Jamieson then instances the cases of two isolated hills—Schïhàllion, 3500 feet above the sea, in Perthshire; and Morven, 3000 feet, in Aberdeen; the former (page 165), glaciated by ice pressing over it from the north. On Morven (3000 feet), he finds erratics that have come from the west; and again, on the Ochils, 2000 feet, he finds the erratics of the Grampian Hills.

I will only just now remark, that these mountains are dominated by still higher mountains in the direction from which he traces the erratics, or denuding agents, to have come; nor must we leave out of view the fact, that most ice-shorn isolated mountains are glaciated in a peculiar manner from the base upwards, and to this I will call your attention further on, but which Professor Jamieson does not explain. What I object to is the supposed analogy of a heap of corn and the ice sheet, which cannot hold. The corn does not move or spread out by reason of the pressure from above acting downwards through the mass, but owing to the gravitation of the outside particles falling down, until the heap has assumed the slope proper to the materials, the same as happens in the case of a mass of sand. Nor can any one imagine that it is the loose snow that glaciates rocks. Grains of corn move downwards by their gravitation, but they could not move upwards; nor can there be any similarity between masses of rounded particles moving upon each other and snow crystals, which lock into each other under the least pressure. I merely allude to the foregoing as calculated to

* "Quarterly Journal of the Geological Society," vol. xxi., 1865.

mislead in the investigation of most striking phenomena, and not from any wish to disparage a paper of the highest merit.

Mr. Geikie—a keen observer and a most pleasing writer—has published a treatise "On the Phenomena of the Glacial Drift of Scotland," reprinted from the "Transactions of the Geological Society of Glasgow," vol. i., part 2; it is full of patient and laborious investigation; and, under the head of "The Old Glaciation of the Country," he describes several extraordinary phenomena, to some of which I have already alluded; and, differing with him as I do upon some points of great importance, I venture to apply the facts as they exist in Donegal to the correction of the errors committed in the explanation of the same geological phenomena in Scotland, which he describes as follows:—Speaking of rock-shearing, *roches moutonneés*, &c., he says, page 22—"But by far the most wonderful exhibition of the worn, mammillated, and striated rocks in this part of Scotland, occurs among the slate hills to the north of Loch Fad—one of a chain of deep fresh-water lakes, which nearly cut the island of Bute into two. The hard metamorphosed Silurian strata dip at high angles towards the south-east, and present, in consequence, their upturned edges towards the north-west. But, instead of forming rough rugged crags, as these rocks when left to themselves tend to do, the slates and grits are shorn down into the most perfectly smooth faced knolls." "The edges of the beds have been planed off obliquely, and the work has been done as cleanly and smoothly as if it had tasked the energies of all the masons in Bute. Moreover, on Barrone Hill, the top of which is about 520 feet above the sea, we see that the abrasion has been done by an agent which *came up* the steep northern face of that eminence, went right over its summit, and pursued its course down into the next valley beyond."

Again—"In short, the fact is impressed upon the observer at every step that some agent of vast erosive power, moving from the north, has come obliquely across the strait that separates Bute from the mainland, passed steadily and triumphantly up and over all the ridges and the hills of the island . . . . has finally passed over into the wide valley in which flows the sea channel that separates Bute from Arran." Again, page 30—"The examples cited from Loch Fyne and Bute show that sloping ground, in place of being furrowed and striated along its declivity, has been smoothed off and scored by an agent which deliberately ascended from the sea level, and, after topping hills of from 500 to 800 feet in height, went down to the sea on the other side." "That the agent did not originate on the hill top, and descend on all sides to the sea, is shown by the fact, that the faces of the knolls and hillocks which looked down the hill to the north are worn and rounded off, while those which look up are rugged and angular. On the south or south-west side, on the other hand, it is the fronts that look *up* the hill which are ground down." "Hence the abrading agent has moved steadily onward from the north or north-east; and so vast must have been its volume, and so resistless its impetus, that hills of 500 or 800 feet in height were little more than mere molehills in its line of march."

Here, certainly, we are "looking the matter in the face." I admit the description of the phenomena. They are beautifully repeated in Donegal in numerous instances, and I have examined some of those in Scotland; but I deny altogether the theory, if it can be called one, by which they are explained—namely, that ice came down along a slope, went into the sea, marched up one side of a hill, and down the other!

I grant the grandeur of all the glacial phenomena, the immense power of its ice sheet; but in contemplating them, and the effects they have left, we must not lose sight of all mechanical and physical laws. No matter how extraordinary and how unaccountable the facts before us may be, science tells us that in these times we have no right to assume the existence of powers for which we have no parallel in nature. The greatest forces in the universe are no more than the developments of its simplest laws. I believe that there is evidence for supposing that there was no such vast and resistless volume of ice as is assumed to have existed at this time; and, if it had existed, it would rather have produced a different effect perhaps. I think I may say that, as a rule, where a high mountain range stands and dominates over lower mountains or hills, particularly isolated hills, the inner sides of those hills are glaciated from the base upwards, and from the top downwards, or else are broken away, or escarped upon the outside in the manner described by Mr. Geikie; and which are, no doubt, often taken for ancient sea cliffs, whereas they are ice cliffs. We have fine examples of this in Donegal; and I would point, as instances of this upward rock shearing upon the inner sides, to such places as Dunaff Head, Doagh Isle, Horn Head, &c., &c., and which are, in fact, merely gigantic *roches moutonnées*. In order to describe how these phenomena were developed, we must inquire into the properties of glacier ice. For any one looking at the agent (ice), and the materials wrought upon (rocks), from a practical point of view, would at once reject the idea of the power of ice to accommodate itself to such a line of motion. I do not, of course, now allude to slight inclinations or undulations in the line of the ice path—such might easily be overcome by the ordinary pressure from behind—we are only talking of very steep ascents of hundreds of feet high.

Glacier ice originates in snow; snow (*nèvè*), under pressure, at a certain depth becomes ice: so that the more you increase the snow beyond a certain amount, the more surely do you destroy its tendency to dispose of itself as pointed out by Professor Jamieson.

Water has the peculiar property, in common with all bodies that expand in solidifying, of having its fusing point lowered by pressure; or, in other words, ice melts at a lower than the ordinary temperature when under pressure,* the rate of lowering being fixed by Professor Thompson at ·0075° Centigrade for every additional atmosphere of pressure.

Now, supposing the lower ice to be reduced by pressure to such a state

* Tyndall, "Heat considered as a Mode of Motion," p. 108.

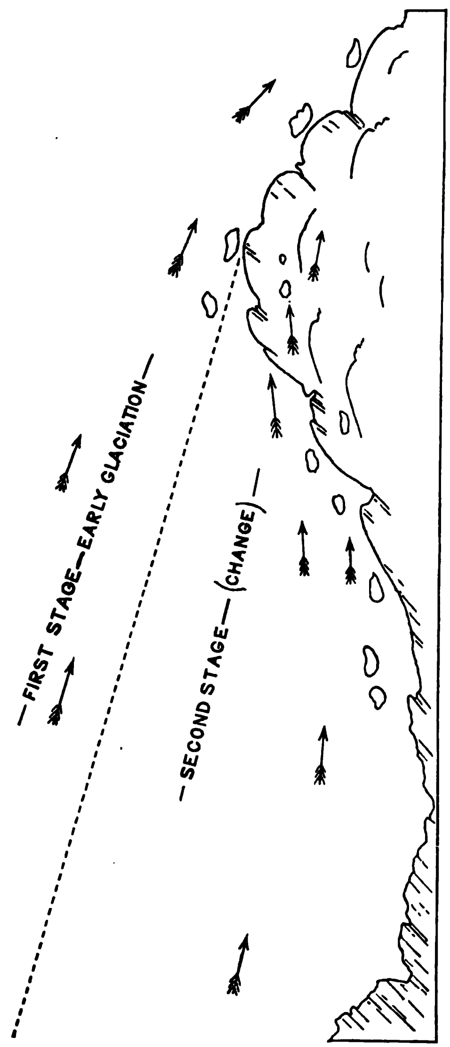

Fig. 5.—Mammillated Hill.

TO ILLUSTRATE MR. HARTE'S PAPER ON THE POST-TERTIARY GEOLOGY OF DONEGAL AND DERRY.

of plasticity or viscosity as to be pushed up under the superincumbent ice, if it is capable of shearing and grinding all the *roches moutonnées* in its path, then it must carry the *débris* with it, and push its own Boulder-clay (ever increasing as it goes along) up the hill before it! And recollect that, if it is contended that those rocks are shorn by this bottom ice, whether in a state of viscosity or not, it must have carried its moraine matter with it; for it cannot be contended that ice alone approaching a state of sludge will grind or groove (though it might polish) solid rocks. And inasmuch as the moraine matter travelling down the incline, through this sludge, would of course travel faster than it would when it began to ascend the hill, it must accumulate in a large body in the hollow, and be forced in that state *en masse* up these extraordinary steep ascents, such as Barrone Hill, in Bute! And here this theory has arrived at such an absurdity, that we might safely abandon it. But, as this theory has been so much relied upon, it is necessary to hunt the matter into a corner before we give it up. I do not think it can be held that ice at the bottom of the glacier could possibly move in this way at all—that is, from below upwards—no matter what its state was, whether solid, plastic, or viscous, except, indeed, as I have said before, over low gradients; for a point exists, as shown by the dotted line (Fig. 5), where the cohesion of the upper and lower ice must cease, and where it would begin to slide along (after the angle of repose had been passed) over the lower ice, leaving it without motion to fill the hollow, filling the hollow between the top of the opposing hill and the main range. And there seems to me nothing beyond a stretch of imagination for supposing it possible that the ice would behave otherwise, and continue to descend, and follow all the undulations of the ground, and then mount ascents of 800 feet. But there is one point which appears to me to demolish this theory at once, and that is the actual situation and form of those hills; and it is to be regretted that men of great attainments do not exhaust the study of local circumstances in the field before having recourse to such violent suppositions as this theory necessitates.

Now, all the fine examples that I know of this upward rock shearing are isolated hills; so are Schïhàllion and Morven Hills, quoted by Professor Jamieson. But I will take the case of Barrone Hill, quoted by Mr. Geikie as such an astonishing example. It forms the northern extremity of the Island of Bute; it is cut off from the mainland by the Kyles of Bute. Its northern face is glaciated by an agent that, Mr. Geikie says, "*came up*" out of the sea. The ascent is steep, say about one to one, for a height of about 520 feet; I speak merely from recollection as to the slope.

Now, the ice sheet which came down from the mainland north of Bute must have surrounded the island, overtopped it, and protruded into the sea at either side—that is, adopting the idea that the lower ice was sufficiently near its melting point to be more plastic than the superincumbent mass. Now, if this was so, it is perfectly impossible to get out of the difficulty that it must have escaped from underneath

the solid ice, and expended its force by escaping into the sea upon either side, instead of, as Mr. Geikie says, "*coming up*" out of the sea, and marching up an ascent of 520 feet, at a steep slope, with every opportunity for its escape round the sides of this narrow end of the Island of Bute. I would say that there is no possible escape from these objections to this theory; and, as I have said before, they are equally applicable to the numerous instances we find of upward ice shearing, and which occurs in so many similar instances of isolated hills. The tourist driving through the wilds of Ennishowen, and in passing through the Gap of Mamore, sees at the opposite side of the cross valley, which lies at the foot of the gorge through which he passes, a magnificent specimen of this rock shearing in the hill called Dunaff Head, which is in fact, as I have said before, a gigantic *roche moutonnée;* and so with several other instances.

I think we must from this abandon the idea of the plasticity of the ice having anything to do with this phenomenon; and if we adopt the idea of those hills being shorn upwards by solid ice, propelled by a *vis a tergo*, and adjusting itself to the undulations of the ground, we fall into equally absurd difficulties; for we must then have a thin but flexible ice sheet, &c.

There appears to me to be another difficulty in the form of those mammillated rock surfaces, for several of them which I have seen never could have been so ground into the rounded form they assume; for, if they had been shorn by a force from below, regularly exerted as it must have been, if at all, the surface would have been shorn flat, and not mammillated.

Having now shown you what, when viewing those phenomena in the field, struck me as an absurdity, I proceed to offer a theory, or rather an explanation, that I think fits in with the facts as they exist, and which relieves us of the difficulties which I have pointed out. Happily, when I started on my investigations, I had no favourite theories to see my facts through; so that, looking about for an explanation by the local circumstances of these undoubtedly at first puzzling matters, I hit upon a solution reasonable, and that does no violence to any law, mechanical or otherwise, so far as I can see.

I have steadily applied my view to every fresh instance I have met: I have met none where I did not at once recognise the same cause for this upward rock shearing. Now look at the diagram (No. 5): There is a hill (Barrone Hill, or any other of those hills you like); its surface on the inner side is marked with a series of *roches moutonnées* from the base to the top, and the same occurs upon the outside from the top to the base. By the inner side I mean the side next the mainland or dominant mountains, from whence the ice stream flowed. By the outside I mean the side furthest from the direction of the ice stream. Now, the grinding upon both sides was not exactly formed either at the same time, or by the same process. During the period of the general glaciation the ice sheet covered the whole of the hill. As it moved off, it ground the protruding rocks on the outside by its passage over them; or, what is

almost always the case, it tore away the rocks upon the lee side, and transported them, with the other moraine matter, down before it. This state of things went on, forming the escarpments which we see upon the sea side faces of our glaciated hills, while as yet the ice upon the inner side had a conservative effect more or less. But now came the change in the conditions of the climate which I have alluded to before, in fact, somewhere about the period which originated the valley gravels; that change may have been very trifling at first, and it may have been very serious and powerful at times. The ice may to a great extent at times have lessened in volume, and then been renewed over and over again. The sculpturings which it left upon those rocks were probably done inch by inch, and the operation extended over perhaps thousands of years, the rough hewing of one century polished by the repetition of the same forces in the next; but, at all events, let the process have been rapid or slow, the forces at work at the period I state, we must admit, were sufficient for the work which was done.

The diagram will show you how I think it was done, not by semi-softened ice, but by the hard upper ice and moraine matter in it; as the ice sheet fell lower and lower, it would abut against the inner face of the hill.

When any thaw took place, it would be next the rock surface; crevassing would then take place along the layers of the ice transverse to its line of motion; then we would have these detached masses striking against each other, sliding along the bottom of the incline, and getting perhaps so much of an upward motion at the end of their slide as to deliver the blow, or thrust, exactly in the direction that would grind the protruding rocks on the hill face into a series of *roches moutonnées.* This action would be aided, too, by the comparatively greater subsidence of the ice in the hollow.

On the flanks of the hill, where it was an isolated one, the hill would be smoothed and rounded off more regularly than the portion which came nearest to the direction from which the ice was coming, and this is what we find to be the case.

Now, I do not mean to crow over my theory, but I ask, is not the operation a natural one, consistent with the operation of forces that we know were in existence at the time I speak of?

It may be objected that we ought to find the Boulder-clay or moraine matter upon those hills, left by the ice as it fell lower and lower, but I do not think so. In the case of isolated hills, at least, the tendency would be for these materials to fall off along the ice slopes to either side; and it was not upon the inner side of those hills, where, as I have said, previous to this the ice had rather a conservative effect, that the Boulder-clay accumulated. It was outside the ridge the Boulder-clay would be deposited, arising from the denudation caused by the ice passing over it; but the ridge acted as a sort of dam to the movement of the ice at its back. Of course, during this process of glaciating the inner side, some comparatively small portion of *debris* must have been deposited; but

even suppose the great ice sheet to have then vanished, the temporary renewals of Arctic or even sub-Arctic conditions would amply provide for the removal of these small deposits again.

So you see my theory is that, instead of the ice having marched up the hill, it marched down, and did its work descending.

Connected with what we have been saying is another feature that I am not aware has been noticed before, at least it was forced upon my attention while examining the previous phenomena. The range of the Mamore hills is a quartz rock that weathers very easily, and its denudation has been something immense, and is even in these times very considerable, particularly, as I pointed out, where the range formed the gate as it were of Lough Swilly.

Now, Dunaff Head is, as I have said, one grand *roche moutonnée*, and at its base are a series of beautiful mammillated granite rocks, or *roches moutonnées;* but, on looking across the valley, the highest hill of the range is a perfect dome-shaped hill, Raghtin More, 1657 feet high, showing that it was subjected to the action of the grinding agent; and yet it now dominates, or nearly so, the rest of the range. Now, taking the major axes of Dunaff and the other *roches moutonnées* as a guide, they point considerably to the westward of this dome-shaped hill, and to the portion of the range that, as I have said, is even to this day undergoing great denudation. It is evident, therefore, that the main ice bearer stood where the range is now much lower, and the reason of its disappearance in recent times is perfectly plain. The whole range is very narrow, and the beds of the rock are tilted up at high angles. It is exceedingly fissile, and at its base there is a large deposit of angular detritus. When the dominant mountain was protruding through the ice sheet, this loose rock was being broken away; but the neighbouring dome-shaped hill was being at the same time crag-rounded, and thus prepared against the effects of weathering when it came to be exposed.

But the chief ice bearer having received no such preparation, but being on the contrary full of open wounds, as it were, it continued even to this day, as I have said, being rapidly denuded.

I have noticed this in more cases than one, and it may possibly aid some future investigators to mention it. May it not explain the occurrence of erratics said to be found on high mountains, but belonging to rocks now found only at much lower levels?

From the solution of this difficulty I turn to another, which I believe to be misunderstood, and as to the origin of the phenomenon some doubt exists namely, that of "Crag and tail." It is placed by Mr. Geikie under the head of the general glaciation of the country. If I understand him right, he attributes the ridging of the Boulder-clay to the same cause as the rock crag and tail.* This Boulder-clay

* The reason given for attributing this form of hills to the action of the ice is, that they point in the same direction, and are therefore, whether of clay or rock, rounded by the same agent; but this is clearly confounding cause and effect.

ridging I have already disposed of, as belonging to diluvial action rather than to ice action. Now as to the rock crag and tail, I do not deny that the outer slopes of the crag and tail rocks are ground down, and to a longer and flatter gradient than the inner sides, and for one reason, that the outer slope was protected while the inner was, as I have shown you, presented to the ice. But [illegible] in the formation of these hills, long and patient investigation through hundreds of instances has convinced me that the ruling feature with scarcely an exception of these hills is, that this peculiar form has been given to them by the tilting up of the beds towards the mountain ranges. The case quoted by him as a familiar example is that of the hill upon which Edinburgh Castle stands, but I think no case can be selected more unfortunate for the theory. Edinburgh Castle stands upon a most unglaciated-looking outburst of basalt, and in running up it tilted up the beds of Carboniferous rocks to the east, which make the tail. Of course I do not deny but that the surface of this hill thus formed may have been glaciated, but certainly the shape of the hill is due to its original structure as a whole, and not to ice action. Moreover you will see, as I pointed out (Figs. 1, 2, 3), that the grinding action of ice upon rocks, as exemplified upon *roches moutonnées*, is opposed to the form of crag and tail.

Crag and tail will almost always exist where the edges of any beds are upturned to the mountain; but where they are turned the reverse way, with the most undoubted facility for being ice-ground, they are shorn in the form I have described for upward rock shearing; and their lee sides are escarped and torn away, and not ground down into "tails." It was not until after the foregoing was written, that I observed the note at page 32 of the "Glacial Drift of Scotland," supporting this view of the case; and I can only say that, if any examples exist of rock crag and tail formed by ice, they must be very rare, and due to some local circumstances exclusively.

An important feature in the glacial phenomena of any district are its Erratics. They belong to all stages of the period, and it is almost impossible to fix with certainty the time of their occurrence. They have been largely drawn upon as proofs of submergence, as having been dropped from floating icebergs. In many instances they occur lying on the bare surface, whether it be of rock or till, which has often been denuded from about them. They form a large portion of the coarser valley gravel, into which I have no doubt they have been washed in sludge from their original position, which was not that of the valley gravel.

Striking examples of this are to be met with in the cuttings of the Lough Swilly Railway, near the Inch station. It is not easy to trace the direction of the granite Erratics on the North-west coast of Donegal, for the simple reason that the granite extends out to the sea from the central ridge, and therefore we have granite Erratics lying upon granite. Not so, however, on the north and east coasts; for there we have the granite ridge succeeded by extensive developments of quartz, mica,

slates, and trappean rocks, upon which we have the granite Erratics lying, clearly traceable to their centres of dispersion, not alone by their mineralogical characters, but by the continuous direction of their streams as well. Nor are we confined to granite alone for these erratics. The granite from whence they proceed is cut across by various syenitic and greenstone dykes, from a few inches to some feet in thickness; they are highly crystalline, and they accompany the granite erratics. Perhaps the finest exhibition of erratics which I know of will be found all along the north coast, but particularly from Gweedore to Dunfanaghy.

Along the Gweedore Valley some fine erratics have been carried out towards the Bloody Foreland—one, a little above the Rectory of Dunlewey, weighs somewhat about 250 tons, carried down whole and entire; it was dropped upon the till, when it split into three large pieces along the lines of bedding and cleavage.

Further on towards the sea, amid the waste of these granite mountains, lying upon the quartz rocks, are quantities of fine erratics, up to 200 tons in weight. Most of the large erratics are angular or subangular; many are rounded, which can be accounted for in more ways than supposing them to have been rolled much; for granite is a rock that decomposes rapidly, and its angles are easily rounded off, both by atmospheric action and friction, arising from denudation around it. Glacier ice will carry along with it very different-looking erratics at the same time. It will bring blocks which, subjected to more or less friction in the ice, will be weathered and rounded; but it will also carry, lying upon its surface, the sharp angular erratics which have burst off from the face of protruding peaks, and may deposit both side by side in its terminal moraines.

It will be seen, then, how cautious one must be in forming any theories by the mere appearances of these erratics; but their mineralogical characters, and their continuous developments, or dispersion from certain points, enables us to trace their origin; and, as I have shown you, I have not found it necessary to fly to Aberdeen for our Donegal erratics, when the centre from which they radiated was close at hand.

I know of no erratics which are not clearly traceable to the higher mountain points; and I know of none that require the submergence theory to account for their position, and none which cannot be accounted for by their having been carried down by land ice.

The Rev. Mr. Close, in his Notes upon the "General Glaciation of Ireland" (page 23), seems to conclude that the larger erratics must have been dropped from floating ice during the submergence of the country after the stratified drift was formed, and after the drumlins and rock striations were produced; in support of which he quotes the fact, that the lines traversed by the erratics in some places is transverse to the drift carriage, but this appears to me by no means conclusive. The force which acted during the greatest intensity of the Glacial Epoch in one direction might act under conditions of lesser intensity down natural valleys transverse to the former direction.

If the erratics relied upon as proving submergence subsequent to the accumulation of all the other drift formation are evidence of their having been so deposited, we ought then to have over the vast areas which the sea must then have swept abundant concurrent testimony in the shape of Arctic shell beds, of which we hear nothing, and the absence of which seems to me to tell strongly against such a theory. The question is an open one, however: I can only say my own experience leads me in direct opposition to the idea of submergence at any portion of the Glacial Period in Donegal; and it is to be regretted that the evidence is so scant upon the subject as regards the rest of Ireland.

There is a feature that cannot well be passed over when treating of this period, though it is not my intention to dwell much upon it here—I allude to the formation of rock basins.

Various theories have been put forward from time to time to account for their formation. They are supposed, for instance, to have been "gouged out" by the action of ice, and at a time when that action was intense. I do not presume to solve all the difficulties of the case, but merely to state what has struck myself as to the phenomena in those cases coming within my own knowledge.

Those rock basins have their greatest length along the line of the natural valley in which glaciers lay, and of the outcrop of the softer, or more easily denuded rocks. Their length too, is more or less conterminous with what I suppose to be the last stage of the local glaciers of the valley. I do not think those glaciers had much to do with their construction; on the contrary, it strikes me that the rock basin belongs to a period somewhat subsequent to the existence of the local glaciers, when the conditions which we see in the present time existed, but on a much more powerful scale—namely, violent alternations of heat and cold. I will instance a case:—Take that of Lough Eske. Here the beds of the Old Red and Yellow Sandstone lie against the granite and hard gniess of the Barnesmore Mountains. The valley originally commenced high up on the col, which divided Lough Eske from the Inver River; it has quarried away those beds, leaving a steep escarpment on the west side of the Lough, and this quarrying process has been carried on to a depth of 70 feet below the sill of the outfall—*i. e.*, the limestone rock at Lough Eske Bridge. The excavated rocks are strewn in all directions westward, but not eastward of the central ridge.*

Now, this part of the valley, in which the Lough lies, must have been constantly filled with glacier ice, which no doubt had its terminal moraine. Into this ice would be frozen the upturned ends of the underlying beds; when the earth began to heat, as these rocks even do at this day to an extraordinary degree in the early part of the summer, avalanches, sudden thaws, and violent floods, would take place round

* *Vide* "Physical Features."

the sides of the basin. The bottom ice would be forced up, the moraine burst, and the ice carrying the fragments of those rocks would float over the mouth of the Lough. Thus, by the simple but powerful action of ground ice, would this excavating process be carried on, and, if only given time enough, there is no limit to its effect. Ground ice is well known as a means of transporting large rocks in times of thaw in the rivers of northern countries; and here there seems to me to be in the case of rock basins facilities for unlimited action. It is essentially a quarrying process, while ice grinding, "gouging," &c., are actions of a very different kind, suitable to smooth-formed bottoms, which our rock basins have not, so far as I know. I am not aware whether these ideas are new, but I have never met with them before.

We have now arrived at the latest of our superficial accumulations, when atmospheric agencies—such as we see them in the present day in these countries, and with probably, on the whole, a similar climate to that which we enjoy—had begun to play their part. No doubt, far back in the valley gravel period they acted also, when the ridging of the "drumlins," kames, &c., was, as I have shown, commenced. But we must not overlook the effects of these agencies later still. Those who are familiar with the writings of Professor Jukes, Colonel Greenwood, Mr. P. Scrope, and others, cannot fail to be struck with the immense effect of rain and rivers on the latest of our geological records.

There is one interesting feature that I am not aware of having been noticed before, which I venture to point attention to. It is the formation of what I may call a very recent arenaceous limestone along our coasts. This is not a sedimentary deposit, but the result of atmospheric agencies. At three places in particular it attains an extraordinary development—viz., at the head of the strand connecting Doagh Island (not an island now) with the mainland, is a ridge of blown sand; again, at the strand at Clommany; and again, along the head of the strand at Ballymastocker Bay.

The blown sand consists of a large proportion of comminuted marine and land shells. This has hardened into regular beds—so hard that it is quarried, and carried away for building purposes, and used as stones for scouring floors, and the like. The beds dip, without any regular joints, at an angle of about 35° with the horizon. They crop out in regular succession for more than half a mile in length, and about 80 yards in breadth. The softer beds are crumbling away, and the sand which composed them is blown away at every storm, leaving the harder beds standing up in grotesque forms, their sections showing admirably that false bedding and contorted stratification which fine sand takes when drifted along, and which we see in the stratified drifts, as well as here, under subaërial conditions. This stone—for I may call it so—is sometimes full of perfect fossils—*Helix nemoralis*, *Patella vulgata*, *Mytilus edulis*, *Cardium edule*, and other shells, same as we find on the sand hills of the present day around.

The appearance of those beds is most striking, and one can hardly suppose when first seeing them that they are not looking at a recent yellow sandstone freshly upheaved.

Lying on these sandhills, and along the shore, I find county Antrim and county Derry flints, in the same way as they are noticed by Professor Jukes* to be found all along the whole eastern and southern coast of Ireland, as far as Ballycotton Bay, in Cork. They are easily accounted for, and are the production of "Eisfodds," drifted round the coast, and stranded by the ordinary currents, such as they are at present. A word here upon the other chalk flints, which are to be found inland, up to a height of 1200 feet, in the counties of Dublin and Wicklow. I think those speak something in favour of what I have been urging as to fresh-water currents (melted ice) passing from some of the coasts inward. They can scarcely be supposed to have been brought overland such a distance without covering the intermediate land too; but if lifted upon ice coastwards, and then pushed inland, they would be easily accounted for, without having recourse to the theory of marine submergence.

Another important feature is the fragmentary condition of the shells alluded to by him as being found in Wicklow as high as 600 feet; and it is even possible, if we admit, as we must, the probable fact that the northern, western, and southern coasts of these countries were blocked with ice, that these shells were deposited in fresh-water loughs, into which they had been floated by ground ice; and their appearance is not, therefore, conclusive as to marine submergence.†

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* "Handbook," p. 675.

† It is well to explain here what may be said of these fragmentary and other shells at high levels. I do not wish to be understood as denying the evidence of glacial marine submergence *in toto*, except in Donegal and part of Derry; but I think, as regards central Ireland, or even Scotland (and we may add Wales, perhaps), that this evidence is not conclusive. If the northern, western, and southern coasts of the British Isles, including of course the mouths of the estuaries, and the channels, were blocked up and ice-packed with icebergs thousands of feet high—and for which we have ample precedent even now in Arctic countries—the land ice would be joined to them; and, when the thaw came, much of these countries (the Clyde valley, central Ireland, &c.), would be under large fresh-water loughs, through which, as the thaw extended coastwards, ground-ice would start up, and float these shells to great heights—aye, and even whole beds of sea bottom might be thus brought up, and melted down as it were apparently *in situ*. We know, too, that icebergs grounding at the mouths of estuaries push immense banks of mud before them. In this way, if after the Glacial Period in these latitudes had passed, and while yet intense northwards, a fresh drift of icebergs grounded upon our coasts, and melted there, they would send this mud inwards, with its newly acquired Fauna, &c.; and, if we had only mud enough and ice enough, this might, under certain circumstances, make "Carses." That some of the shell deposits contain internal evidence of having come from the sea inwards I am inclined to think; but I must reserve what I have to say upon that point. Why we have not the same shells in drift in the cross valley from Muckish Mountain, by Derry, across the Foyle basin, may be fairly asked, and I think it is explained by the fact of the existence of that mountain range so near the north-west coast, which, while it would unite with the great iceberg drift in sending a current inwards, would at the same time act as a barrier, and exclude the entrance of "ground-ice" passing over into the valley with its

Having now traced the Post-Tertiary history of this country, as far as the geological evidence at my command goes, the question will naturally be asked, where are the first traces of man to be found? I can only answer, that I believe them to be met with no earlier than in the kjökkenmöddings which rest on the valley gravels at Inch, and for the particulars of which I must refer you to my paper on the subject.*

That man followed up the clearing of the land from the ice sheet immediately as it disappeared, I think there can be but little doubt, and that he was an eye-witness of the latest phase of the Glacial Epoch I believe there is evidence.

Professor Jamieson, in the able paper which I have quoted already, adduces the names of several places in Scotland to which the term "Inch" is attached, as denoting that, though now considerably above the level of the sea, man recognised them as islands, and so named them. Thus, places now surrounded by "carses," in the mud of which marine Fauna abound, are in Scotland termed islands. We have the same in Donegal, only that we have no "carses."

The latest formation surrounding our "Inches" is the finely sifted valley gravels and brick clays, in which I have patiently, but vainly, searched for any trace of organic remains, and which, as I have said before, I believe to be a fresh-water deposit alone. In my paper upon the Kjökkenmöddings I pointed out the fact, that the country lying north of them is called "Ennishowen," "Inch Owen," or "Innis Eogan;" and stated my belief that the early savages, who constructed those shell mounds, must have seen that "Burt Island," "Inch Island," and "Ennishowen," and the land north of Malin were islands in their time. But when I wrote that paper the systematic investigations detailed in the foregoing pages had scarcely been commenced, and I was not then in a position to state what I believe I have here proved, that, though islands, they were islands in a fresh-water, and not in a marine lough or strait; and, had we at this close of the Glacial Period been subjected to such a depression as Scotland has, we must have had our ancient upheaved Post-Glacial "carses," like Scotland: we only have our present estuarine mud.

Having such good precedent for the introduction of tradition into a geological treatise, you will pardon me if I push it a little further in a matter of no small interest. There is a legend of the greatest antiquity, and which seems to have been a favourite one with the early Irish, that off the west coast of Ireland there is a land submerged, which now and then presents itself to the eyes of a chosen few! Various are the beauties and good things told of it. Spell-bound, it awaits "the good time coming," when it is permanently to reappear. I never saw the man

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shells and sea bottom. It was different in the centre of Ireland, the Clyde valley, &c., for those districts were open to the western sea.

Much of my investigations, both here and in Scotland, had been made and written before the force of these points, such as it is, had pressed itself upon me.

* "Journal of the Royal Geological Society of Ireland," vol. i., p. 154.

that saw the man that saw this; it is always some of the past generations or two ago that saw it last. I was under the impression that it was a legend of the coast of Connemara until after I had commenced these investigations, when I found that it no less belonged to Donegal than to Galway.

Several ancient writers allude to this land of "Hy Brazil," or "O Brazeel;" but I would refer the curious to Hardiman's "Irish Minstrelsy," pp. 368, 369, &c., for the fullest account I have met with of it, and it may not be out of place to allude to it here. The author, quoting, at p. 368, "from the unpublished History of Ireland remaining in MS. in the Library of the Royal Irish Academy," gives the *locus in quo* for this land as,

"Long. 3° 0′ W.
Lat. 50 20 W."

and then gives in full a letter from a Mr. William Hamilton to his cousin. The letter is dated at Londonderry, March 14, 1674.

The writer describes the discovery just made of the reappearance of this island of "O Brazeel," off the north coast of Donegal, by a Captain Nesbitt, of Killybegs. There was great excitement, he states, in consequence thereof, and the gentry were going to see the Captain; and he, the writer, "had it from Captain Nesbitt, his own mouth!"

The writer asserts, too, that this island was inserted in several ancient maps; and it seems that in the sitting of Parliament, in Dublin, in 1663, a Member (the M. P. for Donegal?) assured the House the island was found! But this turned out to be not true; and yet some people were so anxious upon the subject, that one person actually took out a patent for the island, in anticipation of catching it!

While there can be no doubt that the legend of this land of O Brazeel partakes in a high degree of the fictitious as well as the marvellous, I think there is evidence to show that it must have had some grounds for its origin, and was not a mere invention of the early Irish people, but was a fixed idea, springing out of physical facts.

Now, I do not mean to force this subject; but I believe it to be of as much importance as the facts which gave the name of "Inch" to several of the places I have alluded to. Mr. Close endeavours to account for the inequality of level between the western and eastern margins of the central plain of Ireland; and Mr. Kinahan concludes that Ireland rose unequally from her submergence in the glacial sea; as yet this submergence is, I maintain, "not proven;" and I have shown you that in Donegal—where, I assert, there is no evidence in favour of, but almost overwhelming against, marine submergence—we have the same cross currents which have been noticed further south, and which are sought to be accounted for by the somewhat violent supposition of either a more elevated western seaboard, or the existence at one time of a land once higher than, but exterior to, the west coast! Now, we have here, I think, some little inkling of the facts in the fairyland

tradition of "O Brazeel." Recollect that, in a position corresponding in Scotland with that of Donegal in Ireland, Professor Jamieson has lately traced, at the very time when I was working at the same subject here, a cross current, which swept over Caithness from the north-west, and which carried with it the earlier drift deposits (redrifted them), mixed with fragments of Arctic shells, and, remark, swept them across the sea into Aberdeen! Now, I think I can see some explanation of all this. When the change which ensued upon the breaking up of the Arctic conditions of the country took place (a change, as I said before, to be checked and renewed, perhaps often, in succeeding ages), these coasts, as I said before, exposed to the direction of the great northern ice drift, would have piled upon them huge icebergs, to meet which the land glaciers would press down.

The whole coast, and the sea for a considerable distance outwards, would thus become packed with gigantic ice masses, even thousands of feet high, as Arctic travellers have shown; and why need we then look for a cause, in disturbance of the level of the land, when we have here, the moment a further change of climate would take place, an ample supply for these fresh-water currents, which could only flow inwards and across the country to the east, as they did at Caithness?

And as, undoubtedly, man had then begun to inhabit those countries which possessed an Arctic Fauna, he must be more or less ignorant as to the precise line where the lands ended, and the sea began; and, doubtless, often followed in the chase the Bear, the Reindeer, and other Arctic animals, which very likely crowded the ice, as it retreated off the lowlands towards the sea westward. These were his hunting grounds; and we may easily imagine that, when the final *coup de grace* was given to the Glacial Epoch, he saw them with dismay sink from his view for ever. The oft-told story of their existence did not lose in the telling; and each generation, departing more and more from the original, moulded the story to their own ideas; and I only say, with I think some reason, that perhaps we have a glacial origin for our legend of "O Brazeel."

Résumé.

The conclusions to which I would direct your attention from the foregoing are as follows:—

1st. That there is a great similarity in the physical features, geology, mineralogy, and past conditions of climate in Donegal and Scotland—even more so, perhaps, than between Donegal and the rest of Ireland.

2ndly. That, while there have been considerable oscillations of level in Scotland in Post-Tertiary times, there were none in Donegal.

3rdly. That, while there is perhaps evidence in Scotland of submergence to 600 feet beneath the glacial sea, and possibly to the same extent in the midland part of Ireland, Donegal was not included in that movement.

4thly. That even this immobility of Donegal extended far back previous to the Tertiary trappean outbursts of the neighbouring counties of Derry and Antrim, as evidenced by the Tertiary clays, &c., of the Foyle basin only occurring on the east side of it.

5thly. That the Post-Tertiary Geology of Donegal, as described in "Frost and Fire," is irreconcileable with the facts.

6thly. That the most striking and perplexing phenomena of the Glacial Period are due more to the denuding influences of the later changes in it than to the earlier glaciation of the country.

VI.—Notes on parts of South Devon and Cornwall, with Remarks on the True Relations of the Old Red Sandstone to the Devonian Formation. By J. Beete Jukes, M. A., F. R. S.

[Read November 13, 1867.]

On the 13th of August last I was able to escape from my official duties in Ireland, on "leave of absence," in order to take a glance at the rocks of south Devon and Cornwall. I was, however, compelled to return from Falmouth on Sept. 6th by an official summons, on the business of the proposed new College of Science in Dublin, so that my time was limited to three weeks.* Mr. J. O'Kelly, of the Irish Geological Survey, accompanied me on the trip, and as he had formerly spent some years in working among the Old Red Sandstones and Carboniferous slates of the south of Ireland, he was of great use to me both in making additional observations and in correcting or confirming my own.

THE UPPER PALÆOZOIC ROCKS OF MUNSTER.

Full information as to these rocks will be found in the one-inch maps, the six-inch sections, and the pamphlet memoirs called "Explanations," published by the Geological Survey of Ireland. I would especially call attention to the Explanations of sheets 187, &c., and of sheets 192, &c., as containing lists of the fossils of the Carboniferous slate, drawn up by Mr. Baily, the whole of our Brachiopoda having been previously submitted to the kindly-proffered inspection of Mr. Davidson.

The province of Munster includes the counties of Waterford, Cork, Kerry, Tipperary, Limerick, and Clare. If to these we add the county of Kilkenny, we shall have the best district in the British Islands for studying the gradual changes in the thickness and characters of the Old Red Sandstone, and the immediately superincumbent beds belonging to the Carboniferous formation.

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* I give these personal details in order to anticipate the charge of too hasty a mode of proceeding, which might otherwise with great reason be brought against me.

For the sake of reference, perhaps, it will be well to give two tables descriptive of the two extreme forms assumed by these formations in ranging across this part of Ireland, one taken from Kilkenny and Waterford, and the other from the western parts of Cork and the adjacent parts of Kerry.

Eastern Type, Kilkenny and Waterford.	feet.
Coal-measures, ...	3,000
Carboniferous limestone, from	2,000 to 3,000
Lower limestone shale, .	100 to 300
Old Red Ssandstone, from	100 to 3,000

Western Type, Western Cork and Kerry.	feet.
Coal measures about . .	600
Carboniferous slate (including in some places the Coomhola* grits, which vary from 20 feet to 3,000 feet), from . .	1,000 to 6,000
Old red sandstone, upwards of	10,000

It must be recollected that the Coal-measures of Munster and the adjacent parts of Leinster are not like the Coal-measures of the centre and north of England, but precisely like those which have been spoken of as the "culmiferous beds" of Devon and Cornwall. They consist chiefly of hard, dark shales, often cleaved into slates, and interstratified with grey flagstones and sandstones; and their coals are chiefly culm and anthracite. They contain abundance of plants, however, of the ordinary Coal-measure species, while in their lower parts they have a peculiar assemblage of fossil shells, among which may be especially mentiened *Posidonomya Becheri*, *Aviculopecten papyraceus*, *Goniatites crenistria*, and *Orthoceras Steinhaueri*, or *scalare*, which are also found, I believe, among the beds classed as Millstone grit in the north of England, and abundantly in Devonshire. These Coal-measures have the same characters whether they rest on the Carboniferous slates or on the Carboniferous limestone; and in both cases have also yielded fragments of fossil fish, of the genus *Cœlacanthus*, with the other fossils.

It may also be mentioned that there is some reason to suspect that it may hereafter be found necessary to detach the lower part of that which is here included in the Old Red Sandstone in the western district

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* Coomhola is a little glen near Bantry Bay, in which these grits are exhibited in their fullest development. I do not, by any means, wish to use the term as descriptive of a subdivision of the Carboniferous slate that could be separated by a definite line from the rest of the formation. The Coomhola grits are beds of sandstone scattered through the Carboniferous slate, often, but by no means always, showing a peculiar set of fossils. These sandstones occur at different levels in the slate in different districts, but more abundantly in the lower than the upper parts. Sometimes, indeed, the Coomhola grits become so numerous as to coalesce into a group of sandstones 2,000 or 3,000 feet thick; but still there are black slates in them and under them, in which the ordinary fossils of the Carboniferous slate are found. The Coomhola grits are *inliers* of the Carboniferous slate. For the amount of palæontological evidence of the identity between the Carboniferous slate of Ireland and the Devonian rocks of Devonshire, I must refer to the former paper read before this Society in May, 1865.

of Ireland, where it acquires the enormous thickness of 10,000 feet, and upwards. It is not unlikely that some of the lower part of that vast mass may belong to the "Dingle Beds," which, on the north side of Dingle Bay, are separated from the true Old Red Sandstone above them by a wide unconformability, and appear more closely connected with the Upper Silurian beds below them which contain *Pentamerus Knightii* and other Ludlow forms.

It is possible that these Dingle beds may be the same as those which contain Cephalaspid fish in Scotland and Wales, and that these will have to be everywhere detached from the true Old Red Sandstone, and either grouped with the Upper Silurian, or assigned a separate name, as an intermediate formation between the Upper Silurian and Old Red Sandstone proper. They are of vast and unknown thickness both in Ireland and Scotland, in each of which countries they are separated from the true Old Red Sandstone by wide unconformabilities, as shown for Scotland by Mr. Geikie especially. There is no apparent unconformability between them in South Wales, although the Cephalaspid fish occur only in the lower portion; and this may be the case in the Killarney district, in which, however, no Cephalaspid fish or other fossils have yet been found. This question, however, refers to the Old Red Sandstone itself and what may lie below it, and is altogether foreign to the object now in view, which is to give an answer to the question, how far it is correct to call any Old Red Sandstone by the name of Devonian, or to consider any part of it as contemporaneous with the rocks containing marine fossils, to which that designation is fairly applicable.

THE PARTS OF DEVON AND CORNWALL WHICH WERE VISITED.

We reached Newton Abbot* on August 16th, and spent five nights there. We examined the neighbourhood of Chudleigh, that of Torquay, where we had the advantage of Mr. Pengelly's guidance, and that of Ashburton with Dr. Harvey Holl, whom we happened to meet at Torquay. We then spent a week at Dartmouth, examining the banks of the river Dart, as far as Totness,† and the coast from Brixham Quay to Slapton Sands. A night at Torcross enabled us to carry our examition round Start Point. We then made a traverse to the north and west, round by Stokenham, Harlstone, and Sherford, to Kingsbridge, which we made head quarters for three days' excursions—one S. W. to Salcome and Bolt Head, another to the N. N. E., as far as a hill called Black Down, and round eastwards by the hamlet of Bowden to East Allington,

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* Newton Abbot is now the larger part of the town, of which Newton Bushel (the name used in most geological works) is also a part, remaining more nearly in its old state.

† A little to the N.E. of Totness is a place called Boston, and beyond that rises Bunker's Hill. Are these the places from which the names of the much more widely known localities in the United States were taken?

and the third to the N. N.W. through Ugborough, to the Western Beacon of Dartmoor, returning by Modbury and Aveton Giffard.

A day at Plymouth enabled us to examine the country to the east of the Harbour by Plymstock, Bovisand Bay, Langdon, and Wembury. We then proceeded to Liskeard, from which we gave a day to the section from Liskeard to Looe, and the following day I got a hasty glance, between the morning and evening trains from St. Austell, at the country as far south as Mevagissey and Gorran Haven.

It is quite obvious that it would be impossible for any one to do any original work worth mentioning in such a hasty passage through the country. Original work, however, was not one of my objects. These were twofold—1st, to acquire such an enlarged notion of the geography of the country as would facilitate the reading of the published geological descriptions of it; 2nd, to make a personal acquaintance with the rocks of the country.

I must confess that the perusal of geological descriptions of countries I have not myself visited is to me so irksome a task as often to be impossible. The constant reference to a map, which is requisite, the half hours spent in searches for places, to the precise situation of which the author gives no clue, and which, perhaps, after all, are not mentioned in any map, involves such a delay as generally ends in deferring the perusal of the work to that *convenient season* which seldom arrives.

But it is quite impossible for any one to supply by written descriptions a knowledge of the peculiar lithological characters and appearance of different slates, sandstone, and limestones such as would enable another to estimate the amount of their similarity, to the slates, sandstones and limestones, in another district. The Carboniferous slates of the S. of Ireland have peculiar characters such as I never saw in any Silurian or Cambrian rocks anywhere in the world, but they are precisely identical with those of Devon and Cornwall. Any one who has spent months and years in hammering among the Palæozoic rocks of our islands knows that he acquires such a power of recognizing those of different formations as rarely, if ever, leads him astray; but he cannot communicate that knowledge by words; it is as difficult as it would be to give such a description of half a dozen men as would enable one who never saw them to distinguish and identify them in a crowd.

A single eye-glance at a quarry or a cliff gives a far better means of comparison with rocks previously known than the most graphic description that was ever penned.

In examining Cork and Kerry it was found that different observers working in adjacent districts, and trusting to the different lithological characters of the Carboniferous slates and the slates of the Old Red Sandstone, drew boundaries that fitted into each other at the edges of the maps of their respective districts, with scarcely any modification being required, and where the rocks were well exposed, with none at all.

My object in visiting South Devon was to see whether Mr. O'Kelly and myself could recognize the rocks as similar to those of Munster, in

Ireland, and what conclusions that similarity, if it existed, would lead us to. I had previously had the same object in North Devon.*

RELATIONS BETWEEN THE COAL-MEASURES AND THE DEVONIAN ROCKS.

I wished first of all to examine into the unconformity between the Coal-measures and the Devonian rocks, said to be observable in the neighbourhood of Newton Abbot. This is specially described by Mr. Godwin Austin, in his paper, in the 6th volume of the "Transactions of the Geological Society," London, and more or less supported by other observers.

The conclusion we came to from the facts we saw in the neighbourhood of Newton Abbot itself, near Chudleigh, and near Ashburton (all places I had visited many years ago under the guidance of Professor Sedgwick) was, that while the observable facts were such as to be readily explicable on the hypothesis of unconformability, there was no conclusive proof of the truth of that hypothesis. The apparently discordant position of the Coal-measures relatively to the adjacent Devonian beds would, wherever we saw them, admit of explanation on other hypotheses, such as concealed dislocations, unrecognized contortions, and the fact of joints having perhaps been in some instances mistaken for beds.

Even in the cutting on the Totness road, a mile south of Newton, where apparent beds of limestone dip to the northward at a good angle under Devonian slates, and apparently allow beds of similar slate to rise from underneath them on the south, I could not feel altogether satisfied that the apparent stratification of the limestones was the real one. In the large limestone quarry near the lane to the westward of the Totness road, which I visited with Dr. Harvey Holl, I laughingly remarked to him that "one might toss up whether the beds were ver-

* Perhaps it may be advisable for me here to say a few words deprecatory of the spirit in which it appears that this attempt of mine to show the true relation of the Old Red Sandstone to Devonian rocks has been received in some quarters. In controverting a conclusion arrived at by Mr. Lonsdale, and adopted by my revered old master, Professor Sedgwick, and my present chief, Sir R. I. Murchison, and by others who may have preceded, accompanied, or followed them, and accepted without doubt by myself on their authority, till I was forced to abandon it by the simple logic of facts, I hope no one would suppose that I have been actuated by the silly vanity of wishing to bring myself into notice.

It was not of my own seeking that the task of superintending the working out of the geology of the S.W. of Ireland was assigned to me. If the work there done by my colleagues and myself gives an easy and natural clue to the perplexing problem of the classification of the rocks of Devon and Cornwall, surely it would be a dereliction of duty on my part if I hesitated to put the geological world in possession of that clue as soon as I became aware of its applicability.

Some hints have been conveyed to me that this proceeding may be attended with annoyance to some men for whom I have never entertained anything but respect and good feeling. If so, I shall regret it, but I must add, that I can scarcely believe it, or even fully understand its possibility. Surely every geologist will feel more satisfaction at the correction of a geological error than he would annnoyance if the error, or misapprehension, happened to be an involuntary one of his own.

tical or horizontal," for there were planes of division in both directions, either of which might be planes of stratification and the other joints.*

In the lane going to East Ogwell, sandstones and shales come in over these limestones with a sharp twist, that may be either a fault or a contortion; and these seem certainly to be Coal-measures, but the extension of these Coal-measures in the Survey Maps is far too great, most of the area so marked being Devonian slate, and some of it, I think, limestone.

In the quarry, near the corner of the lane going down into East Ogwell, the limestone is well stratified, dipping east at 15°; and green Devonian slates may be seen rising out from underneath it on the west.

Some of the beds of limestone in this quarry consisted of a mass of broken encrinite stems, some of which were a quarter of an inch in diameter; and, to our eyes, it so precisely resembled the crinoidal limestone we were familar with in parts of the Carboniferous limestone, that we doubted whether any one could point out any difference. Mr. Baily says he believes the crinoids in the specimen I brought to Dublin belong to the genus Actinocrinus; but he, of course, does not pretend to decide on the species.

Another limestone quarry, in which the bedding is unmistakeable, is in the lane just west of Abbots Kerswell, where it dips N. E. at 15°, and is broken by small faults. On the Totness road, just west of this, we observed in the slates shown in the ditch cuttings small brown ochrey specks, like decomposed Leperditia (Cypridina).

The slates about Abbot's Kerswell appeared to us to be Devonian, and not Coal-measures, as marked in our maps; and at one place, a little north of the village, at a cross roads, Dr. Holl, on quarrying a little into the dark grey slate, which seemed to be horizontal, exposed a well-marked "stripe," which was vertical, striking E. N. E. and W. S. W.

The only place where we could procure any fossils from the limestones (except the broken crinoid stems before mentioned) was in the quarry nearest to Newton, on the Totness road. I bought what the quarryman had, and Mr. Baily, on examining them for me, identified the following species:—

Atrypa desquamata; Streptorhynchus umbraculum (= *crenistria*); *Spirifera undifera; Leptæna interstrialis? Rhynchonella acuminata; Euomphalus, sp. undeterm.; Orthoceras, do.; Amplexus tortuosus; Bronteus flabellifer; Phacops latifrons.*

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* It is often impossible to determine the bedding in the large railway cuttings and quarries in the Carboniferous limestone near the city of Cork. The planes of division are so numerous and similar, crossing each other at various angles, but each set parallel to each other, that any one set may be stratification and the other joints. Slaty cleavage also in some places affects the Carboniferous limestone as well as the Old Red Sandstone, so that specimens may be got of rough white marble slate.

I could not see or hear of any specimen of *Stringocephalus Burtini*, nor is there any in the Museum at Torquay, so that it cannot be an abundant fossil.

Near Chudleigh, all we could really decide on was, that the sandstones of Ugbrooke Park belonged to the Coal-measures, and the Chudleigh limestone dipping under them was certainly Devonian, as described by Mr. Godwin Austen, and did not belong to the Coal-measures, as supposed by Sir H. T. De la Beche, and coloured in our maps.

In the neighbourhood of Ashburton we first walked up the lane leading to Buckland Beacon. We could not see hereabouts anything that we could recognize as Coal-measures between the Ashburton limestone and the Granite. We certainly got small bivalve shells in the road-side cuttings, near the farm called "Druids," which Mr. Baily afterwards identified as *Orthis interlineata*, *Athyris concentrica*, and *Chonetes Hardrensis*. These occurred within the boundary drawn on our maps for the Coal-measures, and prove the rocks so far to be Devonian.

In the lane to the westward of the "Druids" all the rocks seemed to dip N., or towards the granite; but in that to the eastward, all the observable dips appeared to be south, towards Ashburton.

Going up to the N. W. from Bickington, however (a village three miles N. E. of Ashburton) where the Ashburton limestone dips S. E. at 50°, we almost immediately came on what appeared to be Coal-measures striking E. N. E. and W. S. W., and apparently vertical, and we found similar beds undulating on Ramshorn Down, a little farther to the N.W.

These are probably the same beds as those near Buckfastleigh, to the S. W. of Ashburton, which we did not see. Their apparent position seems to be well figured in plate iv., figs. 5 and 6, of De la Beche's Report, where, however, they are not distinguished from the Devonian beds, except by a slight gap in the drawing.

If the apparent discordance between the position of these Coal-measures and the Devonian rocks near Ashburton be a real unconformity, and the apparent succession of the Devonian rocks south-east of Ashburton be taken as a true one, the unconformity must be very great indeed, since the section would place some 20,000 or more feet of Devonian beds over those of Ashburton, against which these Coal-measures appear to repose.

It is evident from many passages in De la Beche's Report (pp. 69 and 77, for instance), and in the paper by Sedgwick and Murchison, in the 5th vol. of the "Transactions of the Geological Society" of London, that they all felt the great difficulty there was in coming to any certain conclusions as to the mutual relations and real succession of the different groups of rock in this country, partly from the difficulty in deciding between stratification and cleavage, partly from the certainty that there were great concealed dislocations in the country, and partly from the small and scattered exposures of the rocks, and the apparently capricious irregularity in their mode of occurrence. This caprice is specially

indicated by the setting in and dying out of the great "junks" of limestone, as Professor Sedgwick says the workmen call them.

The capricious behaviour and mode of occurrence of the "cleavage" of the rocks about Torbay is well known, but perhaps it is in the cliffs round Mudstone Sands, south of Berry Head, that it can be studied to most advantage, since on the northern corner of the Bay it crosses the beds; in the centre appears to coincide with them; while towards the limestone of Sharkham Point on the south it disappears altogether.

The unconformity of the Coal-measures to the Devonian rocks has also been said to be observable in the neighbourhood of Launceston and Petherwin, in Cornwall. Here, again, however, from my own observations on two former occasions, I must distinctly maintain that the want of conformability is *not proved*. In this assertion I find myself supported by the high authority of Professor Phillips, in a passage at p. 196, in his "Palæozoic Fossils," which had not previously caught my eye; he says: "There is, or appears to be, at Landlake Quarry, some unconformity between the black shaley beds which are at the base of the Carbonaceous group and the grey calciferous rocks of the Petherwin group. These latter dip N. 30° E., and the former dip S. 5° E. The line of valley is here the junction—a circumstance which diminishes the importance of the observation, as a ground for inferring a real unconformity. . . . . There is, moreover, some appearance of a minute reversal of the dip of the black shales at the part nearest the junction."

There is also this passage to be found in the second part of Sedgwick's and Murchison's paper, at p. 691: "One of the authors, during the summer of 1838, re-examined a great part of the transverse section of Devonshire, and was more than ever convinced that, with some ambiguous exceptions, there was on each side of the great trough a true passage from the lower division of the Culm-measures into the inferior fossiliferous group," which was afterwards called Devonian. On the whole, then, I must hesitate to accept this suggested unconformity as sufficiently proved, and must maintain that, before that proof can be arrived at, the whole country will have to be far more minutely and accurately surveyed than it has yet been."*

THE KINGSBRIDGE PROMONTORY.

Under this name we may speak of the district south of a line running from Berry Head to Plymouth Harbour, Kingsbridge being the

* It must be recollected that this country was not really examined by Her Majesty's Geological Survey. Sir H. T. De la Beche did the work "en amateur," at his own cost, assisted by information from Mr. Godwin Austen and others in the geology, and by Mr. W. J. Henwood and others in the mining part. The Government afterwards published the maps on which the information so collected had been laid down, and organized the Survey for the purpose of carrying on and extending the investigation to the whole kingdom. No better geological maps had ever been published up to that time—none whatever on so-large a scale. Our present style of work, as might be expected, is far more minute and detailed than had ever been dreamt of when the maps of the S.W. of England were published.

most central and convenient place from which to examine it. In the most general terms it may be described as a great synclinal trough, the longitudinal axis of which runs east and west, a little south of the town of Kingsbridge, from the middle of Slapton Sands, in Start Bay, to a little south of the mouth of the river Avon, in Bigbury Bay.

To the south of that axial line all the rocks dip northwards; to the north of it they all dip to the southward. This statement is based on all the observations recorded in previous publications, as well as on our own, and is not invalidated by the fact that small local convolutions are occasionally observable, chiefly along the north and south border of the district.

Taking the axis of the synclinal trough, a little south of Kingsbridge, as a base line on the south—and the margin of the Dartmoor Granite, near the Western Beacon, north of Ivy Bridge and Ugborough, as a boundary on the north—we have a band of country, eight miles wide from north to south, in which all the rocks dip south, usually at high angles. If we put the width of the country at 40,000 feet, and allow a mean of 30° to the angle of the dip, we get a thickness of 20,000 feet for *a part only* of the Devonian series, without any definite base or summit to it. Few people, I suppose, will be inclined to accept that conclusion, and it will therefore be at once conceded, that the apparent facts as to the "lie" of the beds are not the real facts, and that instead of a regular succession of beds, one over the other, as we proceed from north to south, the same beds must be repeated, either by faults or contortions; if the latter, by those which are inverted on one side, so that both arms of the curves dip in the same direction.

I may perhaps remark here that we were not aware either of the lie of the rocks, or of their exact nature, when we entered this district, and were prepared simply to accept whatever we might observe ourselves, or find recorded by others.

I will now briefly describe what we saw at each locality:—

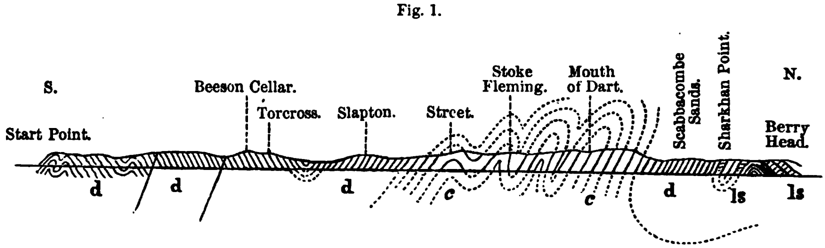
Dartmouth.—First taking the coast from the Brixham Quay and the Sharkham Point limestone to Slapton Sands, we can testify to the general accuracy of the sketch—section No. 6 in Sedgwick and Murchison's paper in the 5th vol. of the Transactions of the Geological Society, London.

The limestone of Sharkham Point, with the ironstone and greenstone dips to the southward, under a series of black slates, full of gritstones and sandstones, often stained of a red colour, but usually of various shades of grey, varying from black to pale gray. Many of the grey slates are like those we have called "riband slates" in Ireland, from their showing alternate laminæ of darker and lighter tints, often slightly waved, and many of the quartzose grits are like varieties of the Coomhola grits, which are interstratified with the Carboniferous slate of Ireland, at different levels in it, but usually in the lower part of it. All these rocks dip steadily to the south, at 40° or 50°, for the space of a mile and a half, as far as the southern corner of the indentation called Scabbacombe Sands. Here that which appears to be the

highest bed of black slate dips under some beds of red sandstone precisely identical in character with the Old Red Sandstones of the S.W. of Ireland—that of Glengariff Harbour, in Bantry Bay, for instance. From this point all along the coast into the mouth of the river Dart, and for some distance farther, not a black or grey slate is to be seen, but still all the red sandstones and slates maintain a steadily southern inclination, generally at a high angle. Mr. O'Kelly and I at once agreed that had we met this section in the S.W. of Ireland, we should not have the slightest hesitation in asserting that the rocks were inverted here, and that this Old Red Sandstone, that seemed to lie over the black slate, came out from underneath it, and had been bent back into its present position.

On studying Sedgwick's and Murchison's section, mentioned above, I am inclined to refer the commencement of this inversion to the Sharkham Point limestone itself, and to suspect the part which lies to the south of the iron mines, and dips south at 60°, to be the same as that to the north of the iron mines, the beds really rising up from below, and being bent back to the northward, as represented in fig. 1.

Fig. 1.



c Supposed Old Red Sandstone.
d Carboniferous (Devonian) Slate.
ls Limestone in ditto.

If the longitudinal axis of this supposed inverted synclinal at Sharkham Point be itself inclined so as to rise to the westward, it would account for the rapid disappearance of the limestone in the direction of Brixham, since that rock would be pinched out to the westward by the closing of the slates below.

If this inversion be established, the section south of Sharkham Point is really a descending, while apparently an ascending one. The thickness between the limestone and the Old Red Sandstone would amount to 3,000 or 4,000 feet, calculating from the observed dips. The northern boundary of this presumed Old Red Sandstone strikes about east by south from Scabbacombe Sands by Kingstown to Kingswear, opposite Dartmouth, and through the centre of the southern part of that town, and all the rock exposed to the south of that line on both sides of the mouth of the river, and in the country on each side of it, and down as far to the S. W. as Stoke Fleming and Street, appeared to our eyes to be the genuine Old Red Sandstone of Killarney and Glengariff.

Black slate shows itself in the road cuttings on the south side of the new street of Dartmouth, and in all the country to the northward, and on both sides of the river Dart, all up towards Ditsham* and Galmpton, all apparently dipping south, or *at* the Old Red Sandstone; but to suppose it to pass under it was to our minds, trained by the much clearer sections in Munster, an impossibility.

We found in many places, as, for instance, near the Dartmouth Dockyard and on the coast near Stoke Fleming, curious igneous rocks, associated with "ashes" and interstratified with the beds, and other igneous rocks, both intrusive and contemporaneous in other places, the occurrence of which is not noted on the Survey maps. It has already been shown in the note at page 74 that these deficiencies are not fairly chargeable to Her Majesty's Geological Survey, as at present constituted.

To the southward of Street the coast section is interrupted for three miles by the Slapton Sands, but we afterwards saw beds, apparently belonging to the Old Red Sandstone, and dipping to the south, for a mile or two to the westward of Slapton village, and passing under black slates, with the same southern dip, as far as the hamlet called Friscomb. A little south of that, but to the north of the village of Stokenham, is a quarry of blueish grey slate, in which the beds rise to the south and dip N.N.W. at 60°, and to the south of that no dip in any direction except to the north was observable till we reached Start Point itself.

TORCROSS AND START POINT.

At Torcross the cliffs show dark-grey and blue-black slates, with green grit bands, dipping north at 85°, underneath which were beds of riband slates, and then more dark-grey slates, in which there was a large abandoned slate quarry at a place called Beeson Cellar. South of this there is a nearly continuous section of Carboniferous slates, interstratified occasionally with grey siliceous grits, and bands of riband slates, all dipping north at high angles, and we found similar rocks appearing right out to Start Point itself. We thought we observed three occurrences of the same set of grey grits and riband slates, with black slates under them, as if brought in again by faults which were downcasts to the south. Without some such repetition of beds there must be a rise here of nearly 10,000 feet of dark-grey slates without bringing up the red beds of Street and Stoke Fleming, which, whatever those beds may be, would be a physical impossibility, since there can hardly be anything approaching that thickness of black slates over them on the northern side of the synclinal axis.

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* In the calcareous band on the north side of the little creek at Ditsham, we found a quantity of fine corals well weathered out, so as to be the best specimens of Devonian corals I ever saw. Mr. Pengelly was so kind as to name them for us, and Mr. Baily concurred with him in recognizing among them the species called *Favosites Goldfussii* and *reticulata*, or *alcicornis*, *Alveolites suborbicularis*, or *Battersbyi*, and *Cyathophyllum Damnoniense*.

We had been prepared by Mr. Pengelley for finding very little trace of the metamorphic rocks which are marked on all geological maps, including those of the Survey, as occurring about Start Point, and extending for two miles to the north of it, but we were certainly surprised at the entire absence of all micaceous or other metamorphic schist.

Near a place called Hall Sands, within less than a mile of Start Point, the black slates became, in some places, minutely crumpled and corrugated, in the way that mica-schist often is. They were also traversed in all directions by quartz veins of all dimensions. About the headland, to the westward of Start Point, some of these quartz veins became coated over with a micaceous glaze, in the same way that quartz veins in mica-schist are often coated, but still the dark grey or black slate was to all appearance the ordinary Carboniferous (or Devonian) slate of the country, except that its excessive and minute flexure and corrugation made it more difficult even than usual to come to any decisive conclusion as to the true stratification and dip of the rocks.

Mr. Pengelly had informed us that the rocks further west, about Prawle Head, were much more micacised than those of Start Point, as we afterwards found those of Bolt Head to be. We had not time to visit Prawle Head, but felt certain, from what we saw of the cliffs stretching towards it, that the mica-schist could be nothing more than metamorphosed (Devonian or) Carboniferous slate, as we afterwards found Bolt Head to be.

MICACEOUS SLATES OF SALCOMBE AND BOLT HEAD.

On landing at Salcombe, we found the dark grey slates distinctly micacised, and yet not to such an extent as to lose their resemblance to the Carboniferous (or Devonian slate) of the rest of the country. The cliffs showed rocks with the same general aspect as those about Kingsbridge, it was only on breaking them open that they were found to present an internal rather foliated structure, and a micaceous glaze, owing to which they might be spoken of as mica-schist. These appearances were analogous to those assumed by the Lower (or Cambro-) Silurian slates of Leinster, as they *approach* the granite, and where they have not yet been converted into the thoroughly metamorphosed mica-schist, which they often (but not always) are when in actual contact with it.

The minutely corrugated structure was also observable in places as we went round Bolt Head, and, as usual, added to the difficulty of determining the exact "lie" of the beds. It appeared to us that the rocks near Bolt Head itself, and for a mile to the westward of it, were nearly horizontal, although traversed by small contortions, as well as often corrugated, and that they dipped to the north about Salcombe, and in the intermediate country. It appeared to us also that the micacisation faded away northwards about the village of Marlborough; but there was not much rock exposed.

We had not time to examine the rocks of Bolt Tail and Hope Cove; but I have since found the description of the latter locality, from the pen of Professor Sedgwick, to give an account of phœnomena so precisely what I should have expected to have seen, that I cannot resist quoting it. It is as follows:—"Immediately to the north of Hope Cove the beds are hard, quartzose, and dark-coloured; and on approaching the junction, they are altered and shattered, and penetrated in all directions by quartz veins. The actual junction *is not parallel to either formation;* but may be traced at low water, in broken zig-zag lines, showing the extreme derangement where the two masses are brought into contact. They seem mutually to wedge into and penetrate one another; and on the south side of the headland is a great mass of black-veined slate notched in among the beds of the older system." (G. S. T., vol. v., p. 658.)

At the time when the above graphic passages were written, the idea that all mica-schist was necessarily older than any clay slate was still so far prevalent among geologists, that even the minds of these distinguished observers failed to perceive how much support was lent, in the above clearly described facts, to the view that there were not two formations, but only one, variously altered, and partially converted into mica-schist.

The influence, whatever it was, which effected this change, had reached the limits of its action, and affected different parts of the slates differently, according to local variations in its intensity, or the varying susceptibility of different parts of the rocks to its agency.

I should be inclined to suspect that a boss of granite may be approaching the surface in this region, and perhaps reaches it under the sea in the adjacent parts of the channel.

THE NEIGHBOURHOOD OF KINGSBRIDGE.

A band of grey slate, affording roofing slate, seems to strike from Beeson Cellar (south of Torcross), for at least five miles to the westward, passing to the southward of Charleton on Kingsbridge inlet. Many old slate quarries have been worked along this band; and in those which we visited to the southward of Frogmore, and at Beeson Cellar, the stratification seemed to coincide with the cleavage, which was vertical, striking east and west.

The beds on each side of the slate band all dipped to the north. This northern dip continues as far north as Stokenham, Frogmore, and Charleton; but a little farther northwards they all dipped to the south. Beds so dipping were seen along the east and west line, which would pass by Friscomb, Keynedon, and west Alvington. Another east and west band of slate quarries seems to cross the promontory in the latitude of Buckland Tout Saints, which lies about three miles to the N. E. of Kingsbridge, whereabouts all the beds dip to the southward. As these two lines of slate quarries seem to be about equidistant from the axis of the Kingsbridge trough, they may fairly be pronounced to be the same beds cropping on each side of it.

To the northward of this, in the line of country in which we expected to meet with the western extension of the Dartmouth Old Red Sandstone, we failed to find it. The black slates, sometimes "raddled," appear to be the principal rocks, but there are some remarkable pale yellow sandstones full of quartz veins, which show themselves on Camp hill south of Morleigh, and on Black Down, three miles to the westward, and are traceable still further west about Heathfield, and then run in a regular band past Stubston (a mile south of Modbury) to Torr (north of Kingston), near the mouth of the Erme River.

These sandstones, which are partially indicated by engraved lines on the Survey maps, very much resemble some of the "yellow sandstones" of Ireland, a term by which it will be recollected Sir R. Griffith designates some beds which lie about the top of the Old Red Sandstone, or in some cases above it in the Carboniferous Limestone.

We also saw some red rocks very like the Dartmouth rocks in the road cutting south of Loddiswell (three miles north of Kingsbridge), dipping south at 60°.

To the northward of the latitude of Modbury, however, the dark grey, or black, Devonian (or Carboniferous) slate, seemed to be the prevailing rock up to the borders of the granite of Dartmoor, with occasional small calcareous bands, as shown in the Survey maps.

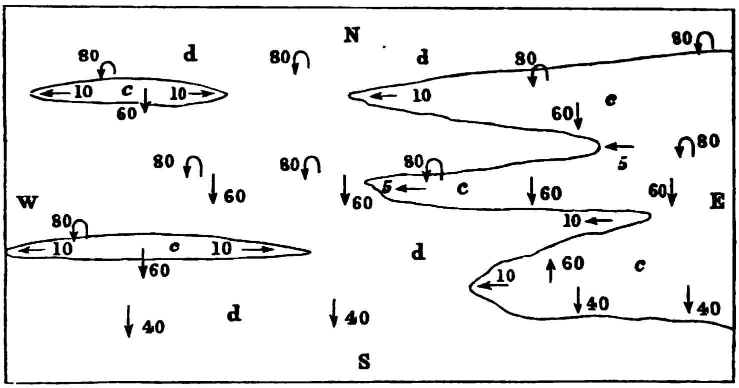
A line of slate quarries in which the beds seem to be perpendicular runs about east by north, and west by south in the neighbourhood of Ugborough, and I would venture to speculate on these being the same beds as those in the two bands in the Kingsbridge trough, brought in on the northern side of the inverted anticlinal, which I certainly believe crosses the Kingsbridge promontory, about the latitude of Dartmouth.

Dr. Harvey Holl has been kind enough to send me his notes, made subsequent to our visit, while he was traversing the Kingsbridge Promontory. The general results of his observations agree with ours, so far as the observable facts are concerned. He, however, rather favours the notion that the change of character observable in the rocks, as they are traced along the strike from Dartmouth, is due to an original lithological variation in the nature of the rocks at the time of their deposition, and considers the Dartmouth red sandstones to be the upper rather than the lower part of the series. While not in the least denying the possibility, or even the actual occurrence of such variation, I am, on the other hand, more inclined to attribute this apparent variation to the occurrence of different beds along the same general strike brought in by unseen complications in the position of the beds.

When we recollect the large areas over which the Old Red Sandstone can be seen to preserve great lithological similarity, as, for instance, across South Wales, and the south west of Ireland, it appears to me that the occurrence of similar beds in Devonshire is much more suggestive of their original continuity with those of the other areas, than of the repetition of peculiar lithological types with intermediate variations.

The apparent variations in the beds, as we observe them at intervals, when following their strike, is readily explicable in a district convoluted as I believe south Devon to be. Suppose fig. 2 to represent a map of a country containing two formations *c* and *d*, *c* being the undermost, and that they are bent into a series of folds, the northern sides of which are inverted, as indicated by the bent arrows, so as to make the general dip appear to be always to the south.

Fig. 2.



If the longitudinal axes of these folds rise and fall along the strike, the lower formation will rise to the present surface of the ground, or sink beneath it, so as to be covered by the upper, in conformity with these undulations of the longitudinal axes. If I may use the cant phrases of the Survey, the lower formation will be apt to "nose in" under the upper, as we follow an anticlinal ridge, or the upper formation will "nose out" over the other, as we follow a synclinal trough. If these flexures are sharp, and especially, if these folds are pushed over so as to have one side inverted, the actual exposure of one of these "noses," either in natural or artificial excavations will probably be a rare occurrence. One such instance, however, on a small scale, was actually seen by us in a quarry on Morleigh Camp Hill, though there was no appearance of inversion there, but merely a north and south flexure, tilted so as to slope downwards along the summit of the fold towards the west.

Beds belonging to one formation might readily pass in this way beneath those of another formation in the direction of the strike, without any apparent change in the direction, either of the strike or the dip, being observable in the few scattered localities where the rocks were exposed. Instances of this structure occur not unfrequently in the S. W. of Ireland.

THE GROUND ON THE EASTERN SIDE OF PLYMOUTH HARBOUR.

In the paper by Sedgwick and Murchison, in the 5th vol. of the "Transactions of the Geol. Soc.," London, the rocks on the eastern side of Plymouth Harbour, which apparently lie above the Plymouth Limestones from Mount Batten to Wembury, are subdivided into five groups.

The two first of these are spoken of as slate or "shillat;" the third, which terminates southwards at Bovisand Bay (just opposite the eastern end of the breakwater), is said to consist "of bright red, sometimes variegated, sandstone, thick-bedded, and of coarse texture, but subdivided by bands of soft glossy red slate and red micaceous flagstone." "This division, in many parts, is exactly like the Old Red Sandstone, and though thrown into violent contortions, it dips, on the whole, towards the south, and is of great thickness."

The fourth group, south of Bovisand Bay, is said to be "earthy slate, with nodules of ironstone* containing fossils," beyond which are "reddish slate and flagstone, and coarse red sandstones.

I would venture to suggest here also the possibility of these beds, "so like the Old Red Sandstone," which lie to the northward of Bovisand Bay, being brought up by an anticlinal, accompanied by inversion as well as by contortion, and that this inversion may even affect the southern borders of the Plymouth limestones themselves. There is something very peculiar in the aspect and mode of occurrence of these limestones. Their sudden thickening and expansion, and their equally sudden terminations, so as to form "junks" of limestone, are such as are not common at all events. The occurrence of inverted synclinals tilted along the strike would account for them.

At p. 654 of the above paper, when speaking of these limestones and the slates interstratified with them, it is said that there are "some flexures in the inferior slates which hardly seem to affect the great overlying masses of limestone, and produce what we regard as a deceptive appearance of discordant stratification." Such appearances would be likely to occur among beds that had been so violently disturbed as to be inverted, but I do not recollect any case where beds that had merely been tilted up into an inclination of 30° exhibit such appearances.

It is afterwards said that the rocks of this section, extending from "Mount Batten to the cliffs opposite the Mew Stone, bear the closest resemblance to the red arenaceous rocks in the cliffs east of Coombe Martin in North Devon." But the rocks in the cliffs east of Coombe Martin (which I believe to be the same as our Coomhola Grits), certainly dip under the Coombe Martin limestones; and if the Coombe Martin limestones are on the same horizon as the Plymouth limestones (which everybody seems to suppose probable at least), it is a strong argument

* Are these the bull's eyes which occur in the Carboniferous slate of Ireland and parts of North Devon?

in favour of inversion occurring at Plymouth, and that the sandstones which seem to lie over the limestones there really come up from under them, as they certainly do in North Devon.

Professor Phillips also, in his description of the east side of Plymouth Harbour ("Pal. Foss.," p. 201), especially likens the red grits, often ripple-marked, which occur there, to those of his "Martinhoe" group in North Devon, by which I have no doubt he intends that group of sandstones inter-stratified with the grey slates which strike through Trentishoe and the Hangman Hill, as well as Martinhoe, and which he correctly describes as lying above the Lynton black slates.

From these descriptions, I am inclined to suspect that the sandstones on the east side of Plymouth Harbour may be on the parallel of our Coomhola Grits rather than the actual Old Red Sandstone; but on this point, as the weather did not allow of our examining the cliffs themselves, I can give no decided opinion, nor is the point of any consequence.

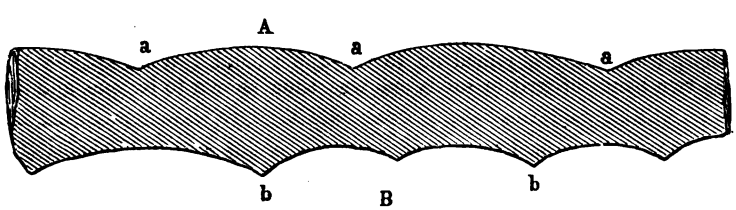
All I would suggest is the probability of their real place being considerably under that of the Plymouth Limestones, and not over them, as it appears to be.

In passing from the limestone at Plymstock to Goosewell and Staddiscombe, we saw several exposures of dark bluish black slate of the usual Devonian (or Carboniferous) type. We went from the village of Down Thomas into Bovisand Bay by the southern path, which leads down to the sands. On the southern side of the sands we found dark grey Carboniferous slate in the cliffs, at first dipping at a high angle to the north, but immediately contorted to the south.

On the northern side of the sands we found first grey slates, interstratified with hard grey siliceous grits, dipping south, but contorted. Immediately beyond these we came on some purplish grits and shales, some of the surfaces of which were rippled. This was a structure I had been anxiously looking for as likely to throw light on the question of inversion.

On rippled surfaces the little ridges and furrows are sometimes so equal and similar that there would be no sensible difference between the original surface itself and a cast of it. It often happens, however, that while the ridges of the ripple are broad and smooth, the furrows between the ridges show a sharp little indentation at the bottom.

Fig. 3.

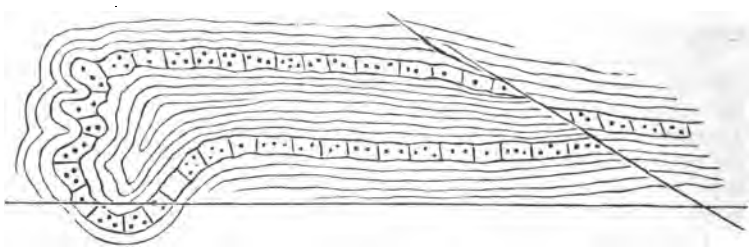


[One-third of natural size.]

Fig. 3 will illustrate this. It is taken from a tracing of the edge of a slab of sandstone, reduced to one-third the natural size. This slab exhibits a well-marked ripple on its upper surface, A, while on its under surface, B, is the cast of the ripple which was formed on the bed below. It is evident, if the reader will turn the figure upside down, that the small projections marked *b*, *b*, could not be formed on the summits of the ridges, but that they are the casts of little channels like those marked *a*, *a*, formed at the bottom of the furrows, and, therefore, that the surface A was the original upper surface of the bed,* and B the cast of the ripple on the bed below.

In some crags, from which some blocks had recently fallen and left the *under* sides of the beds exposed to view, but protected from the weather, we found what was certainly the *cast* of the ripple (or current mark) and not the ripple itself, so that it was plain that those beds were not inverted, but right side uppermost.

Fig. 4.



Diagrammatic Sketch of Contortion in Bovisand Bay.

While engaged in noting these circumstances, however, Mr. O'Kelly had scrambled over the rocks into the farthest little cove accessible at half-tide, and, on my joining him, called my attention to a contortion of a most remarkable character.

At the corner of a cliff of about forty feet in height beds of grey slate lay horizontally, and in them lay what seemed at first to be two beds of white siliceous gritstone, about three feet thick and ten feet apart. A small fault occurred near the corner of the cliff, which brought down the upper grit band nearly on a level with the lower. Beyond that the grey slates and grits ran regularly and horizontally for about twenty-five yards, when the lower bed became contorted. It was bent sharply down, and then curved up again; and after several small but sharp convolutions, joined on to the upper band. What appeared to be two bands of grit or sandstone was thus shown to be one and the

* I think it was in the year 1847, while at work with my colleague Mr. Aveline, near Corwen, in North Wales, that this observation occurred to me. It enabled us to ascertain that some sandstone beds in the neighbourhood were inverted, and, if I recollect rightly, helped to explain their otherwise anomalous position.

same, the beds being convoluted and bent back on themselves in the way shown in Fig. 4.

After examining this contortion I must confess that I became more than ever impressed with the utter uselessness of any one endeavouring, by detached observations, to unravel the confusion into which the rocks of South Devon are thrown. Nothing short of a thoroughly exhaustive survey of the whole country, under the guidance of a clue derived from some other country where the same rocks lie more nearly in their natural order and original positions, will suffice for this purpose.

Although we had no doubt in our minds at the time of the correctness of our observations, I must confess to a natural misgiving afterwards as to whether we might not possibly have made some mistake.

I wrote, therefore, to Dr. Harvey Holl, to ask him to visit the spot, and confirm or correct our observations, and received from him a reply, from which he has permitted me to publish the following extract:—

"I am afraid I failed to find the spot you indicated at Bovisand Bay,* but I found two other examples of flexure so similar that I have little doubt but that you were right in your conjecture that there was only one band of grit. My examples are at either end of a short sea-wall, immediately underneath the fort, and to the north of the road to Down Thomas. In the one case the flexure is vertical, in the other horizontal, and in both the point of flexure is broken off; but in the latter it is made good in a receding portion of the cliff. See Fig. 5. Now I had no doubt but that in both cases there is but a single band of grit doubled back upon itself, and yours is probably a similar instance."

Fig. 5.

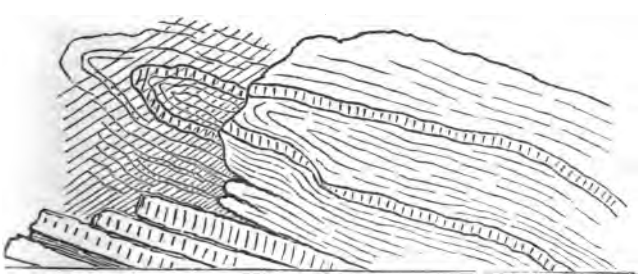
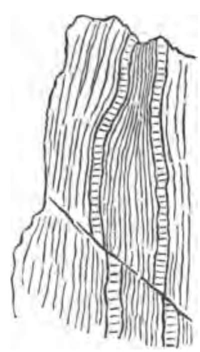


Fig. 6.

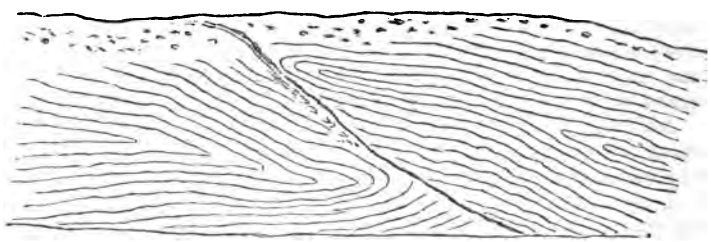


This letter was written from Launceston, and he goes on to say—"I have to-day seen another remarkable case of flexure at Landue Mill, three miles S. by E. of this place. The rock was a kind of black chert." (See Fig. 7.)

* Dr. Holl appears to have taken the path leading to the fort, and not that leading to the sands.

He says the latter sketch was a rough one, made in the twilight, but I have no doubt that it gives us a sufficiently accurate representation of the facts.

Fig. 7.



[Length of Section, about forty yards.]

It is doubtless to some such extraordinary convolutions of the beds that Professor Phillips alludes at p. 197 of the "Pal. Foss.," when he says that "in the same quarry the dips at the surface often contradict those at a small depth," and that "in a single face of rock the beds are unequally contorted, and show a sort of unconformity between one another—as in descending the hill from Launceston to Landue."

I think also that it is to some such anomalies of position that some of the appearances of local unconformity between the Devonian slates and the Coal-measures about Newton are due.

After seeing the contortions at Bovisand, we felt the utter uselessness of continuing our observations, even if we had had time for it. If beds could lie horizontally, bottom upwards, for 25 yards, that inversion being only to be proved by the discovery of the small locality where the actual curvature of a distinct and recognizable bed happened to be exposed, what was there to forbid the possibility of beds lying in that position for 250 yards, or even 2,500, or more, and yet no direct evidence of that fact being anywhere accessible? What trust could be reposed, then, in sections that seemed even of the clearest character? How far could we be sure as to which was the real ascending, and which the descending, order of succession?

I had already, on one or two former occasions, looked at the sections between Plymouth and Tavistock, and once walked along the railway cuttings and gone up to the borders of Dartmoor, without being able to make anything out of the country, and often without feeling at all sure of the real dip of the rocks. The descriptions of that district by all former observers seem to me to be equally barren of any certain results as to the grouping of the beds.

We accordingly hurried on from Plymouth to Liskeard, in order to have a glance at the Looe beds.

SECTION FROM LISKEARD TO LOOE.

Immediately to the southward of Liskeard we observed a few places where the beds dipped to the north, but after this they all appeared to dip to the south or south-east, at angles varying from 20° to 50°. Beds of brown sandstone occurred at intervals, and beds of grey siliceous grit, both similar to rocks that occur in the Carboniferous slate of Ireland.

The blueish-black slates (with occasional purplish tints) that strike along shore round Hannafore Point, the western headland of Looe Bay, reminded us most forcibly of similar exposures of slates along the coast of Cork, and there was an equal similarity in the forms of the cliffs and the scenery of the country.

Among the partially rounded blocks that had fallen from the cliffs on to the beach, on the east side of East Looe, we found some full of fossils, and carried some of them away with us. These, on being opened by Mr. Baily, in Dublin, yielded to him the following fossils:—

	No. of Specimens.
Orthis interlineata?	5
Orthis *hipparonyx?	13
Streptorhynchus crenistria,	6
Spiriferina cristata,	very numerous.
Crinoid joints (? Actinocrinus),	a few.
Branching corals (? Chaetetes),	one or two.

ST. AUSTELL TO GORRAN HAVEN.

My object in making this hasty traverse was simply to see whether there was any mass of rocks which I could recognize as Old Red Sandstone, between the Devonian slates and those coloured on the maps as Silurian, round Veryan Bay.

I am bound to confess that I had previously never inquired as to the reason why this Silurian colour was introduced, and was entirely ignorant of the paper by Professor Sedgwick in the 8th volume of the "Q. J. G. S. L." That paper was published at a time when I was leading a lodger life in the south of Ireland, directing the progress of the survey, having scarcely any place to keep books, and little leisure or inclination to read them.† It was not till we returned to Dublin the

* These are certainly identical with Mr. Davidson's figures in Pal. Soc. Brach., pl. 17, figs. 8 and 12; but Mr. Davidson doubtfully refers this fossil to the above species of Vanuxem and Hall. They are supposed to be Lower Devonian.—(Note by W. H. Baily.)

To this I would add a query of my own, as to why the beds should be called Lower Devonian? The beds of the coast there are the highest in the neighbourhood, and a thickness of several thousand feet of beds seems to rise from underneath them towards Liskeard.—J. B. J.

† Constant active work and exertion in the open air certainly incapacitate the mind for study in a way and to an extent that few students are aware of.

other day that I discovered this paper. All that I had noted myself I found to be in entire agreement with the statements in it, as to the character and lie of the rocks. The vertical beds in Mevagissey, and those down in Portmellin, seemed to me to be the ordinary Carboniferous slate, neither did I observe any noteworthy change in Gorran Haven or the country about it. There was certainly nothing at all resembling any variety of Old Red Sandstone.

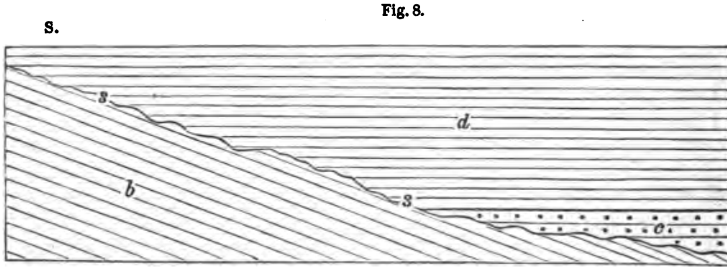
Professor M'Coy, however, who accompanied Professor Sedgwick in that trip, recognized among the fossils got from Peraver* and Great Carn (north of Gorran Haven) the following species:—*Orthis elegantula, parva, calligramma, turgida, flabellulum, testudinaria,* and *retrosistria, Calymene brevicaptitata* and *parvifrous* and *Homalonotus bisulcatus;* and among those from Port Caerhayes in Veryan Bay, *Orthis grandis* of Sowerby (a Bala species) and a species of *Cycloceras.*

These are fossils found in the formations called Lower Silurian by Murchison, Cambrian by Sedgwick, and Cambro-Silurian by Professor Phillips and some other geologists. There are said to be no Devonian species at the above localities, while there are certainly no Silurian or Cambro-Silurian species at Looe, or any other places where the Devonian species occur.

From what I saw of the rocks, and from the study of the section in Professor Sedgwick's paper since, and taking for granted Professor M'Coy's determination of the species to be correct, I should propose the following hypothesis for the explanation of the facts:—

The Veryan Bay rocks were an old slope of Cambro-Silurian rocks which at one time existed as dry land, with its beds and its surface dipping gently to the north, as in Fig. 8. Depression then commenced

Fig. 8.



during the Old Red Sandstone period, and continued during the Carboniferous period. The Old Red Sandstone would be first formed on the beach of this old land and in the water outside it, and, on the continuance of the depression, the Carboniferous slate would naturally overlap the Old Red Sandstone, and spread further and further over the sinking land, resting directly on the Silurian rocks.

* There is a place called Pabeer on the Ordnance Map, but no Peraver.

At a subsequent period disturbances took place; the Silurian rocks were uptilted from the low dip to the north, set on edge, and eventually inverted so as to dip south at a high angle, and appear to overlie the Carboniferous slate, as they are shown to do in Professor Sedgwick's section.

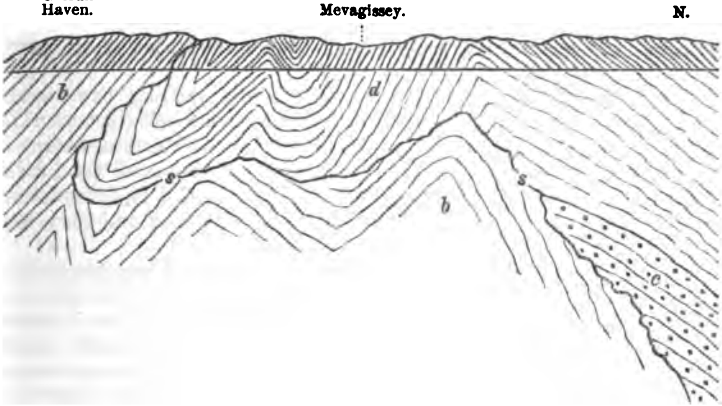
The following Figure (9) is one suggested by that section, with the addition of the supposed surface to the Silurian rocks, and the introduction, to the north, of the Old Red Sandstone, buried by the suggested overlap of the Carboniferous slate.

Fig. 9.

S.
Gorran
Haven.

Mevagissey.

N.



This hypothesis would give a natural explanation of the present state of things.

I would also beg the reader to remark that this inversion, so clearly proved by the fact of Lower Silurian rocks appearing to overlie and dip from the Devonian (or Carboniferous) slate, is very nearly in the same strike with the supposed inversions in Plymouth Harbour, and about Dartmouth.

This fact seems to lend strong support to the hypothesis of inversion which had forced itself on us when examining those places. I may mention also that I was entirely unaware of this at the time; and if the honest truth must be told, came away from Gorran Haven with the impression that there were no Silurian rocks there at all. It was only on my discovery of Professor Sedgwick's paper since my return, and finding the Cambro-Silurian age of those rocks so distinctly testified to by Professor M'Coy's determination of the fossils, that I bowed to such definite authority, and afterwards perceived that their conclusions as to the position of the beds really confirmed my

own previously formed opinions as to that of the beds occurring in the same strike some fifty or sixty miles to the eastward.

It is not perhaps altogether out of place if I remind the reader that in the south of Ireland, between Mallow and Killarney, the Coal-measures dip at the Carboniferous Limestone, which dips at the Old Red Sandstone hills; the beds of which dip south, or away from the limestone, and that this inversion is continued for forty or fifty miles along the strike.

In Belgium, on the other hand, I may remind him of the well-known inversions in the Coal-measures, and those mentioned as occurring among the Devonian and other rocks in Sedgwick's and Murchison's paper on the Rhineland in the sixth volume of the "Transactions of the Geological Society," London, on the authority of M. Dumont.

NOTES ON SOME PREVIOUS MEMOIRS DESCRIPTIVE OF THE WEST OF ENGLAND.

STRATIGRAPHICAL.—*Old Red Sandstone.*—In reading over again lately some of the most prominent published memoirs and papers on the Devonshire district, when better able to appreciate them than before, I was struck by finding several passages strongly favourable to the main conclusion which I had come to, namely, that the Old Red Sandstone was a distinct formation from the fossiliferous Devonian and subjacent to it.

The object which Professor Sedgwick and Sir R. I. Murchison chiefly had in view in their examination of Devon and Cornwall, the results of which are described in their paper in the fifth volume of the "Transactions of the Geological Society," was the separation of the Coal-measures (or Culmiferous beds, as they were called), from the lower fossiliferous slate rocks, to which the name of Devonian was afterwards applied. This is distinctly stated by Professor Sedgwick himself at p. 2 of the eighth volume of the "Quarterly Journal of the Geological Society, London," when describing his subsequent examination of the rocks round Veryan Bay in company with Professor M'Coy. Their examination of the Devonian rocks themselves then was evidently such a hasty one only as sufficed for this object.

I might, however, have used many passages from their paper, instead of my own words, in support of the sketch map and section of North Devon which I published in the pamphlet entitled "Additional Notes," &c. In speaking of the Quantock Hills, for instance, they say at p. 638, that their north-eastern flanks are "composed of soft unctuous slate, not unusually of a red colour,* here and there highly calcareous and sometimes passing into thick irregular masses of limestone. . . . From beneath these rises a system of beds, . . composed of hard and

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* I have several times pointed out that much, but not all, of this red colour crosses the beds irregularly, and is due to subsequent ferruginous staining. I have spoken of such beds as "raddled."

sometimes coarse sandstone alternating with some fissile, micaceous masses of finer structure, and with masses of soft rotten slate." Crossing the Williton valley to the hills about Dunster, they find "a repetition of nearly the same rocks, viz., a series of reddish soft slates, in some places highly calcareous, and containing beds of limestone resting on an inferior system of harder texture enclosing many beds of flagstone, shillat, and reddish sandstone, here and there almost passing into a conglomerate form. The upper series is well exhibited on the eastern skirts of Croydon Hill. The lower, with all its modifications, is finely exposed in Croydon Hill, Grabbist Hill, and North Hill, and is of very great thickness." . . "In this part of Somersetshire the strata are contorted, the hills discontinuous, and the sections broken, yet the main fact we have just stated, viz., the existence of a *lower formation*,* of coarse, arenaceous rock, often of a red colour, and of an *upper formation* of calcareous slate, is established on sufficiently clear evidence."

"The strata of North Hill are cut off . . . . . to the westward by the bay and valley of Porlock. The same system of beds, however, re-appears on the west side of that bay, and is continued to a headland,† a little N. E. of Lynmouth, forming a noble succession of red cliffs and a well defined ridge running parallel to the coast along the whole of this line; the beds strike about W. N. W."

Again, at page 645, when speaking of the northern part of the Quantock Hills, and the hill near Minehead called the North Hill, the rocks are said "to pass into a conglomerate of red sandstone with quartz pebbles not distinguishable from the conglomerate of the Old Red Sandstone," and subsequently "considered as a whole, and from mineral characters only we might compare some parts of this group with the most characteristic portions of the Old Red Sandstone."

I arrived at the same conclusions from my own examination of the district, and described and mapped these *two formations* as the lower part of the Carboniferous slate of Ireland, and the upper part of the Old Red Sandstone.

Mr. Godwin Austen, in his paper in the "Q. J. G. S." vol. xxii., page 3, speaks of the rocks about Porlock as "the only‡ portion of the North Devon and Somerset Palæozoic series, which bears any resemblance to the Old Red Sandstone group of Wales and Gloucestershire." He also mentions the occurrence of plant remains in these beds, which, judging by the frequent occurrence of plant remains in the upper part of the Old Red Sandstone of Ireland, and their occurrence in the same beds beneath the Carboniferous Limestone of South Wales, is precisely what I should have expected.

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* The italics are mine.

† Called the North Foreland.

‡ I presume my friend, Mr. Godwin Austen, meant the only portion which had come under his observation.

Professor Harkness, however, informs me that he has examined these specimens of Mr. Godwin Austen, and doubts their organic character.

But Professor Phillips, in his "Palæozoic Fossils" p. 183, speaks of the occurrence of impressions or carboniferous stains of plants near Lynton, about the line of junction of the red and grey grits with the dark slates, and of the abundance of Fenestella and Favosites, Crinoid stems and Brachiopods in the latter. These are precisely the kinds of fossils, vegetable and animal, which occur in so many parts of the South of Ireland at the junction of the top of the Old Red Sandstone with the beds above.*

I can have, therefore, very little doubt resting on my mind that, in the hills of the coast of Somerset between the Quantocks and the North Foreland we have the true base of the whole series of the Devonian rocks, and that that base is the top of the Old Red Sandstone. I feel also convinced that the Old Red Sandstone spreads under the whole of the fossiliferous slates of Devon and Cornwall, and appears here and there from under them in consequence of faults and contortions, of a more or less complicated and obscure character. Its absence in the neighbourhood of Veryan Bay, in Cornwall, and possibly other places, may be due, as previously shown, to its overlap by the Devonian (or Carboniferous) slates.

The descriptions of the coast of North Devon by De la Beche and Phillips contain a more correct grouping of the rocks on the coast, to the westward of Lynton, than do those of Professor Sedgwick and Sir R. I. Murchison—since the latter authorities suppose that the rocks which stretch from Porlock to the North Foreland strike into the coast again between Lynton and Combe Martin. They seem to have been misled—partly by the ferruginous staining of the cliffs to the westward of Lynton, and partly by having assumed that the valley of the East Lyne was a "valley of elevation," and therefore traversed by an anticlinal axis. If ever there were such a thing as a "valley of elevation" in nature—which I must be bold enough to deny—this is not one, since the same dark-grey slates and grey grits stretch across the valley, in places contorted, but dipping to the south for the most part; though in the lower (or Lynton) end of the valley they are bent into a shallow synclinal trough, rather than an anticlinal.

The grits which form the coast about Martinhoe, Trentishoe, and Hangman Hill, strike to the E. S. E. into the northern part of Exmoor, in a direction parallel to that of the Old Red Sandstone range of the coast; and these Trentishoe and Martinhoe grits and slates represent our

* I have lately been informed by the Rev. W. S. Symmonds that plants of the genus Knorria have been recognized hereabouts, exactly the genus which is locally so abundant in parts of the topmost beds of the Old Red Sandstone in the south of Ireland. Having collected fragments of the same genus in the red sandstones north of Braunton, west of Barnstaple, on a former occasion, strengthens me in the belief that they are the same beds.

Irish Coomhola grits, and contain at intervals casts of bivalve shells (*Cucullæa*, *Myalina*, &c.), and casts of shells like *Natica*, as described in the pamphlet styled "Additional Notes." These grits are an expanded form of the Marwood sandstones, just as at Coolkirky, in Co. Cork, the Cucullæas occur in brown sandstones not exceeding 20 feet in thickness, but which expand as they range to the westward, till in Coomhola, near Bantry Bay, they become grey siliceous grits, with a total thickness of 2000 or 3000 feet, but still interstratified with thinner bands of Carboniferous slate, and underlaid by some of it.*

Both Sedgwick and Murchison, and De la Beche and Phillips, in describing the band of red rocks which strikes from Morte Bay, through Dulverton, to Wiveliscombe, recognize their resemblance both to the rocks of the north coast and to the Old Red Sandstone of other districts.

At p. 643, for instance, of Sedgwick and Murchison's paper, the red rocks in the gorge of the Barle, north of Dulverton, are said to be "hardly to be distinguished from the red sandstone of the second group," namely, that on the north coast.

They speak, however, of these Dulverton rocks striking into the Brendon Hills (misprinted Brandon in their paper), which they did not visit. Had they followed these rocks to the eastward they would have found them striking through Haddon Down, towards Wiveliscombe, with the same E.S.E. strike that prevails in the Exmoor region.

In "Siluria," also (p. 294, 3rd edition, p. 272, 4th edition), Sir R. I. Murchison, speaking of the rocks of this band, says—"Here again we have a partial return to the character of the Old Red Sandstone, for the brown and grey flagstones pass into a red sandstone hardly to be distinguished from the inferior red rock of Lynton, while others are of greenish-grey and brownish sandstone, resembling varieties of the Upper Old Red Sandstone of Scotland." As I was equally struck with their resemblance to the Upper Old Red Sandstone of Ireland, and as there is really no *proof* to the contrary, it seems to me that the safest conclusion is, to suppose that they really are the Upper Old Red Sandstone, and that the beds on the north coast of Devon and Somerset, which so closely resemble them, are really the same beds.

But I find, on referring to Professor Sedgwick's paper in the 8th volume of the "Q. J. G. S. L.," that I can also quote his authority in

* I observe in some recently published papers that the word "Coomhola" is used as if it were a synonym for "Carboniferous Slate." This would, however, be almost tantamount to using the word "Marwood" for Devonian. It is quite possible that parts of the Carboniferous Slate, even where it is 5000 feet thick, do not contain any grits at all; other large parts of that formation only contain bands 20 feet thick or so, while in other parts groups of sandstones 2000 or 3000 feet thick appear. Wherever these gritstones do make their appearance they are apt to contain a peculiar set of fossils—*Curtonotus Cucullæa*, and other Conchifers especially; but they do not always contain them, large, tracts of the grits never having yielded a trace of a fossil, although the common fossils of the Carboniferous Slate may appear in the black slates, which are interstratified with the grits and those which lie underneath them.

support of my own conclusions with respect to the Dartmouth rocks, for at page 3 he expressly mentions the resemblance of the Dartmouth rocks to those of the Morte Bay and Dulverton groups of North Devon, but remarks on the absence of beds representing the Marwood and Barnstaple beds, to the southward of the Dartmouth group. If, however, the rocks of Dartmouth are inverted on their northern side, the Marwood beds (or Coomhola grits) would be represented there by the grits interstratified with the slates in the northern part of Scabbacombe sands, and the Barnstaple beds by the fossiliferous slates and limestones of the Brixham and Torbay country.

These same beds, where they take the ground to the southward of the Dartmouth sandstones in the Kingsbridge trough, have indeed lost their fossils* and calcareous bands; but then it will be recollected that this is nothing more than what happens to the Torbay and Plymouth beds when followed along their strike. In Ireland, also, there appear to be large tracts where the whole Carboniferous slate is unfossiliferous from top to bottom, or at all events in which no search of ours could discover fossils, and these tracts are intermediate between others in which fossils were found in abundance at different levels in the formation.

This irregular distribution of organic remains, indeed, is what occurs in all other similar formations.

Carboniferous Slate.—In the paper by Professor Sedgwick, in the eighth volume of the "Quarterly Journal of Geological Science, London," descriptive of the tour by himself and Professor M'Coy, I find also passages strongly corroborative of the identification of the dark slates of Devonshire with the Carboniferous slate of Ireland which had long previously been insisted on by Sir R. J. Griffith. At page 7 it is said that "Sir R. Griffith's original statement of the very near agreement of the Carboniferous slate of Ireland with the groups just noticed is completely confirmed by what we saw this summer."

Professor M'Coy also, in the "Palæozoic Fossils of Cambridge," when speaking of the rocks of Padstow (on the north coast of Cornwall), and other localities, says that they struck him as so perfectly identical with the Carboniferous slates of Dr. (now Sir R.) Griffith that he asked and obtained Professor Sedgwick's permission to describe the fossils as belonging to that formation ("Palæozoic Fossils, Cambridge," p. 74), rather than to the Devonian. The occurrence of *Cucullæa*, *Curtonotus*, *Avicula Damnoniensis*, and numerous other Devonian forms† in the Carboniferous slate of Ireland, was not then known.

Professor M'Coy adds, that he had since recognized many of the fossils from Tintagel, &c., in the ordinary Carboniferous Limestone of Derbyshire and other places.

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* Mr. Pengelley has collected fossils near Torcross, but Mr. Davidson found them too imperfect for determination.

† Those of Marwood, Baggy Point, and Braunton.

Palæontological.—Although always taking the interest in fossils which every geologist must feel, I have yet rather avoided the attempt to acquire any specific palæontological knowledge. This arose doubtless from a consciousness of my own want of that power of minute and precise observation which is necessary to discriminate between closely allied species of either living or fossil forms.

But I believe I was also not wholly uninfluenced by a dread lest I might be tempted to name and describe a new species—a proceeding which has always seemed to me equivalent to volunteering to take the part of popinjay at an old Scotch wappenschaw, and setting one's self up as a mark for every other palæontologist to have a shot at. I, of course, bow to the authority of those skilled and practised gentlemen who devote so much labour to the delineation and description of species of fossils, but it cannot be denied that most of the new palæontological works that appear are almost as remarkable for the number of new species as for the more welcome slaughter of many of the old ones.

Much of this kaleïdoscopic change is doubtless inevitable in the present state of the science, but it certainly must, while it lasts, tend to diminish the value of palæontological evidence (so far as species of shells, &c., are concerned), except when it agrees with, and is supported by, unmistakeable stratigraphical facts.

On this subject there are some passages in the paper by Professor Sedgwick in the eighth volume of the "Quarterly Journal of Geological Science, London," which I cannot help quoting :—

"No good classification either of subdivisions or systems, or of subordinate formations, ever can be attempted without a previous determination of the physical groups. The study of fossils based on ascertained physical groups may produce, and often does produce, some modification of our lines of demarcation, but the evidence of sections must ever remain as the primary basis of geology. When a system has been well made out, and its groups of fossils determined, we may then make use of comparative groups of fossils freely, and with very small risk of mistake. But to begin with fossils, before the physical groups are determined, and through them to establish the nomenclature of a system, would be to invert the whole logic of geology, and could produce nothing but confusion and incongruity of language."

But surely this is what has been attempted with respect to the Devonian groups. If the Coal-measures are really unconformable on these rocks in Devonshire, where is the section by which their place in our series can be stratigraphically established, and how are we to know what is next them either above or below? Their exact place in our series is apparently supposed to be fixed by palæontological evidence; but even that wholly fails to establish their contemporaneity with the Old Red Sandstone, since those two groups have not a single fossil in common, except one scale of an Old Red Sandstone fish (Phyllolepis) got from Devonian slates, and now in the Museum at Torquay.

The identification of the so-called Culmiferous beds with the true Coal-measures, especially those of the Kilkenny coalfield, can be proved

both by lithological and palæontological evidence, and there is no stratigraphical evidence against it.

The calcareous bands which occur in the lower part of those Coal-measures by Barnstaple, Bampton, and Holcombe Rogus, in North Devon, and along the northern border of Dartmoor, in south Devon, have been assumed to be the representatives of the whole of the Carboniferous Limestone. I am not aware that any remarkable palæontological evidence can be brought forward in support of this assumption. These so-called Culmiferous Limestones are not very fossiliferous, and the fossils which they contain are such as also occur in the lower part of the Coal-measures both in other parts of England and also most abundantly and universally in the south of Ireland. The assumption, then, that these calcareous bands represent the Carboniferous Limestone simply rests on the other assumption, that the beds below them are older than the Carboniferous Limestone.

The strongest palæontological evidence in favour of the latter assumption is the occurrence of trilobites of the genera *Bronteus* and *Phacops*, &c.—genera which also occur, though under other specific forms, in the Silurian rocks, and also the occurrence of certain genera of Brachiopods and Corals, which likewise occur as genera or sub-genera in the Silurian rocks; but not in the Carboniferous Limestone.

The Devonian slates and limestones also contain a number of genera and species which are supposed, with more or less certainty, to be peculiar to them, such as the genus *Clymenia* among the Cephalopods, and numerous species of Brachiopoda, and some Corals and other forms. Every one agrees, however, that there are in the Devonian slates and limestones a number of undoubted Carboniferous species, and I believe that the number of these species thus generally allowed to be common to the Carboniferous Limestone, and the Devonian slates and limestones is much greater than the number of *species* common to any other two formations as distinct in age as these two are commonly supposed to be.*

It is obvious that the genera and species which are peculiar to the Devonian rocks are of no value as evidence of the exact position of those rocks until their true place in our series has somewhere been fixed by independent stratigraphical evidence derived from clear sections.

But the number of those peculiar forms has, I believe, been exaggerated, under the influence of preconceptions as to what the stratigraphical position of the Devonian rocks really is, and also in consequence of that imperfection in palæontology which is every day in course of improvement.†

* If instead of the number of species we were to reckon the number of individuals, I believe the predominance of those common to the Carboniferous and Devonian rocks would be vastly in excess of those which are peculiarly Devonian.

† It will be recollected that all the fossils originally collected by Sedgwick and Murchison were in the first instance assigned to Silurian species.

I learn, for instance, from the pamphlet lately issued by M. Barrande, under the title of "Cephalopodes Siluriens de la Bohême," of which he has kindly sent me a copy, that he has come to the conclusion that the position of the siphon in Cephalopodous shells is really of no generic, nor even of specific value, but varies even in individuals of the same species at different periods of growth. Clymenia, therefore, is nothing more than a Goniatite that happens to carry its siphon in front, instead of behind, if I may use the expression. He says, at page 8—"A nos yeux les différentes positions des siphons out perdu toute valeur, pour caracteriser les genres de la famille des Nautilides," and afterwards, "que le siphon ne possede la fixité du position qu' on lui avait supposée, ni dans toutes les espèces d'un même genre, ni même dans les individus de diver âges, dans certains espèces." Again, at page 14, he says—"Enfin, nous ne pouvous pas dissimuler, que la consequence inévitable des vues que nous exposons entrâinera l' association de Goniatites et de Clymenia." He then goes on to show how impossible it has always been to distinguish with certainty between the genera *Goniatites* and *Clymenia*, where the siphon was not visible, and that the most acute observers have been at fault, Beyrich having shown that one of V. Buch's *Goniatites* was a *Clymenia*, and that a *Clymenia* of Sandberger was a *Goniatite*, and V. Guembel having transferred three of Count Munster's *Goniatites* to *Clymenia*.

This determination explains the occurrence of *Clymenia* in the Carboniferous Limestone of Ireland in Mr. Gilbertson's cabinet, as mentioned by Professor Phillips, and the assertion frequently made to me by my predecessor, Dr. Oldham, that *Clymenia* had occurred to him not uncommonly in the Carboniferous Limestone of Cork.

The palæontological evidence then derived from the genus *Clymenia* that the Devonian rocks are a separate formation from the Carboniferous not only fails, but turns the other way, and is in favour of the beds containing it being contemporaneous with the Carboniferous formation of which the genus Goniatites is so markedly characteristic.

Among the Brachiopoda, Mr. Davidson gives the following species as occurring abundantly in the Devonian rocks, which every one knows are also abundant in the Carboniferous Limestone:—*Rhynchonella pleurodon*, *reniformis* and *pugnus*; *Strophomena analoga*, (*var. rhomboidalis*); *Streptorhynchus crenistria*; *Producta scabricula* and *reniformis*; *Discina nitida*; and *Lingula squamiformis*.

He mentions also five other species which are not so abundant. Besides these fourteen undoubted Carboniferous species, he also gives twenty-four possible species, but of which he has some doubts. Among these is *Chonetes Hardrensis*, which I certainly found most abundantly along the cliff walk at Lynton; Mr. Baily being my authority for the specific name.

In the description of many other species from these Devonian rocks Mr. Davidson often expresses great doubts whether they are really distinct from similar species found in the Carboniferous Limestone, and

gives accounts of similar vibrations of opinion among distinguished palæontologists both at home and abroad (see for instance page 80 of his "Devonian Brachiopoda" in the publications of the Palæontographical Society). But it appears to me that the number of species of which the specific characters are thus doubtful might have been largely extended, or rather, that many of the Devonian species might have been at once amalgamated with Carboniferous Limestone species. Knowing the hard-working, conscientious, and trustworthy character of my valued friend, Mr. Davidson (if he will allow me to call him so), I should certainly not feel inclined to put any one's authority in competition with his, *except his own;* but this, I hope, he will pardon me for doing, in one instance which seems to me to afford so striking an example of the unconscious influence of pre-conceived ideas, even on so sagacious a mind and so practised an eye as his. I could never see any appreciable difference between the species called *Spirifera striata*, from the Carboniferous Limestone, and that called *Spirifera Verneuillii*, or *disjuncta*, from the Carboniferous (or Devonian) slate, except perhaps a little finer and more frequent striation in the latter. I compared Mr. Davidson's figures and descriptions, and they seemed to me to be equally applicable to the same species. I place the descriptions in parallel columns below, transposing the sentences describing the Devonian form, so as to correspond in order with those of the corresponding parts in the description of the Carboniferous one, and ask the reader how far he can suppose these two descriptions to apply to really different species. It appears to me that Mr. Davidson, having at different times different specimens of the same species before him, rather differently preserved, was unconsciously led, in his care to be accurate, into the use of almost the same words in describing them:—

CARBONIFEROUS BRACHIOPODA, p. 19. *Spirifera striata.*	DEVONIAN BRACHIOPODA, p. 24. *Spirifera disjuncta (Verneuilii.)*
(1). A very large and variably-shaped shell, transversely semicircular or sub-rhomboidal. (2). Valves almost equally convex. (3). In the dorsal valve the mesial fold is of moderate elevation; (4) while the sinus in the opposite one is both variable in its width and depth. (5). The hinge line is either a little shorter or as long as the greatest width of the shell, the cardinal angles being more or less rounded in adult individuals. (6). The area is of moderate width with sub-parallel sides, fissure triangular and partially covered with a pseudo-deltidium. (7). The external surface of the shell is ornamented by a variable number of radiating ribs, which augment in number to a greater or less extent, from intercalations at unequal distances from the beaks; so that from seventy to ninety may be counted round the margin of each valve in adult indivi-	(1). Shell variable in shape, transversely semicircular, or sub-rhomboidal. (2). Valves convex, sometimes gibbous. (3) In the dorsal valve the mesial fold is sharply defined, of moderate convexity, and elevation. (4). In the ventral valve the sinus is concave; beak produced and moderately incurved. (5). Hinge line usually as long as the width of the shell, with the cardinal angles slightly rounded, or extended to a greater or smaller extent in the shape of long attenuated contrasted prolongations. (6). Area triangular flat or concave, and of greater or smaller dimensions; fissure partly arched over by a pseudo-deltidium in two pieces. (7). The surface of each valve is ornamented by from forty to ninety small radiating ribs, with interspaces of almost equal width.

duals. (8). The ribs on the fold and sinus are likewise more flattened than on the lateral portions of the shell. (9). The surface is closely and finally reticulated. (10). In the interior of the dorsal valve, under the extremity of the incurved umbonal beak, there exists a small cardinal process, or muscular fulcrum, and on either side are situated the dental sockets. The spiral cones which fill the larger portion of the shell are attached to the extremities of the inner socket walls. The lamellæ, after having converted and given birth to the crural processes, diverge, and form the first of the twenty or twenty-two convolutions of which each spiral is composed. Four impressions left by the adductor muscles are visible in this valve. In the interior of the ventral valve a strong inch-tooth is situated on either side at the base of the fissure, and is supported by a vertical shelly plate of much strength, but not advancing to any great length into the interior of the valve. Between these a large portion of the free space at the bottom of the shell is occupied by the adductor and cardinal muscular impressions, which are divided by a blunt, central, longitudinal ridge. (11). The dimensions of one of the largest examples are:—

Length 4½ inches.
Width 6 inches, 1 line.
Depth 3 inches, 1 line.

(8). The ribs are simple on the lateral portions of the shell, but increased in number to a small extent on the mesial fold and sinus, by means of intercalated ribs, which appear at variable distances from the beaks. (9). The whole surface is crossed by numerous fine contiguous concentric lines. (11). Dimensions variable, some very large examples having attained as much as two or more inches in length, by three or three and a half inches in width; but the larger number possessed smaller proportions.

The sentences numbered 10 in the description of the shell from the Carboniferous Limestone have none corresponding to them in that of the Devonian one, owing to the difference in the state of preservation of the shells from the two kinds of rock.

On examining the excellent figures in Mr. Davidson's beautiful work, which are drawn and lithographed by his own accomplished hand, and printed and presented to the Society at his own expense, it appears to me that a similarity is observable equal to that in the descriptions. There is great diversity and variability of form in the five figures devoted to *Spirifera striata*, and still greater among the twenty-two figures of *Spirifera Verneuillii*, or *disjuncta;* and it appears to me that the diversities are quite as great among the figures of each species as those that are to be seen when comparing the figures of one species with those of the other. The only constant difference that I can trace in the figures is the rather finer and more numerous striation, or ribbing, of the *Spirifera Verneuillii* when compared with the *Spirifera striata.*

All geologists must feel indebted to Mr. Davidson for his incorporation under one name of the suggested species *calcarata, extensa, gigantea inornata, protensa, grandæva, distans, archiaci, Lonsdalei, Murchusoniana,*

and *Barumensis*, and also for putting under the other name those called *attenuata*, *princeps*, and *clathrata*, and his suggestion that *Mosquensis* and its synonyms should also be placed under it. I would, however, beg leave, as an outsider, to ask him, and all other palæontologists, whether there are really any good grounds for retaining more than one name for the whole assemblage?*

I have only brought the above case forward as an example of a reform which I think will have a much wider extension in the future. I could never appreciate the differences, for instance, either by reading the descriptions, looking at the figures, or examining the specimens, between the Devonian shell, variously called (*Leptæna* or) *Strophalosia caperata*, or *Strophalosia productoides*, and the common *Producta scabricula* of the Carboniferous Limestone. I am quite willing to allow that this may arise from the deficiencies of my own powers of observation; but at the same time I must assert that I am by no means alone in this want of power, for, in conversation with a good many other geologists, I have found them quite ready to acknowledge an equal incapacity to recognize the distinctions between these and other species of fossils.†

I believe that in many cases the specific determinations of the palæontologists have been influenced, unconsciously to themselves, by taking it for granted that the place of the Devonian rocks had already been shown stratigraphically to be below the Carboniferous series, and that therefore the fossils *ought* to be different.

The assumption that the calcareous bands in the lower part of the Devonshire Coal-measures represent the whole Carboniferous Limestone has had much to do with this mistake, and then, as usually happens in such cases, the misapprehension acted and reacted on the minds of both classes of observers; the stratigraphical geologists depending greatly on the palæontologists, and the palæontologists supposing the order and succession of the beds to have been already established stratigraphically.

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* I got rather a good lesson in the various forms that a species of Brachiopoda is apt to assume, in the year 1845, when acting as naturalist to Her Majesty's Ship "Fly." In searching for shells on the south side of Port Jackson, about half way between Sydney and the Heads, I found that by wading along the foot of some cliffs at low water, and groping into the crevices of the rocks, and feeling under their ledges as far as I could reach, that I came upon nests of Terebratulæ (Waldheimia Australis), hanging from the rocks. They varied so much in size and shape, that the late W. Sharpe Mac Leay, who then lived in Elizabeth Bay, and whose name every naturalist will recollect, proposed to make three species out of the first batch I procured. As they seemed to me to occur in family groups—parents and children, uncles, aunts, and cousins—I doubted this specific distinction, and after collecting two or three hundred of them, it was plainly perceptible that the variations in size and outline, and in external marking, which went from perfect smoothness to deep ribbing, so graduated into each other, that no definite distinction could be introduced among them.

† I am fully aware that in making these remarks I expose myself to the reception of a rather strong objurgation from some of my palæontological friends. I can only comfort myself in the possession of a very pachydermatous habit for all kinds of objurgations, except such as rouse an echo in my own consciousness.

CONCLUSION.

I now beg leave—not in any spirit of dictation to my brethren of the hammer, but simply as a statement of the conclusion to which some years of thought and work have gradually conducted me—deliberately to affirm that the Old Red Sandstone cannot be classed with the Devonian slates and limestones without a violation of all the rules and logic which govern our geological nomenclature. They are two "formations," as distinct from each other as are the Old Red Sandstone and the Carboniferous Limestone. I believe that the Old Red Sandstone lies wholly below the Devonian slates and limestones, which contain marine fossils, both in Munster and Devon. As to the exact relations between the Carboniferous Limestone and those Devonian slates and limestones, I do not wish to dogmatize upon a question which I believe to be open to further investigation. Where they both come together in the county of Cork, the Carboniferous Limestone is uppermost; but neither of them have any such thick development there as in neighbouring districts, where it occurs alone.

Both groups of rock have Coal-measures* resting upon them, and both rest upon the Old Red Sandstone. These are stratigraphical facts which admit of clear ocular demonstration even in Devonshire, and are obvious in Munster. The exact interpretation to be put on the palæontological facts, when those are also established beyond all reasonable doubt, is, I think, a question for the future.

In the meantime, I must hold to the opinion that after the period during which the Old Red Sandstone of the British Islands was formed a sea spread over these districts, in parts of which mechanically-formed rocks—mud and sand—were accumulated, so as to form a thickness of several thousand feet; and that, during either a part or the whole of the time, other parts of that sea to which the muds and sands did not extend became the receptacle of the Carboniferous Limestone, formed chiefly from the growth of marine animals; and that in some places these accumulations produced a mass 2000 or 3000 feet in thickness. Subsequently to the formation of these groups of rock came the period in which the Coal-measures were spread over them both, having a very variable structure in different places, but chiefly consisting of mechanically-formed muds and sands.

I can only briefly allude to the various igneous rocks which accompanied the formation of these aqueous rocks in Devon, or to those that have been subsequently intruded in among them. The

* That the beds at Ballyheedy, in the county of Cork, are Coal-measures resting on Carboniferous slate, is shown not only by the occurrence of remains of fish of the genus Cœlacanthus and Palæoniscus, but by their being accompanied by the usual Coal-measure shells, *Aviculopecten papyraceus*, *Posidonomya membranacea*, *Lunulacardium sp.*, *Goniatites crenistria*, *Orthoceras cinctum*, *scalare* and *lineolatum*, and also by many plant stems, some one or two inches in width, and finely striated leaves of *Næggerathia dichotoma*, as determined by Mr. Baily, and mentioned in his catalogue of fossils in the "Explanation" of that sheet of our maps.

Granites of Devon and Cornwall are obviously included in the latter category, as well as the Elvans and other granitic and some trappean varieties of rock. Numerous and large fissures and dislocations have subsequently traversed both igneous and aqueous rocks. Some of these have more recently become the receptacles of spars and ores, and are now mineral veins. Other similar fractures and dislocations have since then cut the older ones, and some of these have also become the receptacles of spars and ores. It is difficult to say how often these actions have been repeated; neither is it easy even to guess at the greater or less amount of disturbance that accompanied the intrusion of the Granite. The disturbances that have certainly affected the rocks of the country may have been mostly produced previously to the intrusion of the Granite; or, if they accompanied that intrusion, they may have been greater in the districts intermediate between the present surface bosses of Granite than they were in their immediate neighbourhood.

These and many other similar problems—some, perhaps, yet even undreamed of—lie awaiting the future labours of geologists in the west of England; and if the results of the labours of my colleagues and myself (in addition to those of other Irish geologists, among whom Sir R. J. Griffith takes the first place), in working out the geological structure of Munster, contribute to clear the ground for the commencement of future researches in the west of England, and in making more perfect the classification of these rocks in the rest of the world, it will be felt as the highest reward to which we could aspire.

POSTSCRIPT.

Since the foregoing paper was written there have appeared in the "Quarterly Journal of the Geological Society of London," two Papers on North Devon—one by Mr. Townshend Hall, of Pilton; the other by my colleague, Mr. Etheridge. The map given in the latter paper seems to me to contain a good rough sketch of the distribution and arrangement of the outcrops of the rock groups visible in North Devon and West Somerset. Had I never examined any other Devonian district, I should be quite disposed to accept both the map and sections as good approximations to a complete sketch of the Devonian formation, and agree with Mr. Etheridge in his supposition that the rocks of the North Foreland, Porlock, and Dunster area, (his Lynton sandstone), might belong to the lower part of the Old Red Sandstone, and also that the grey slates and sandstones that lie between it and his Pickwell-Down sandstone (which he accepts as Upper Old Red) were interstratified between those two groups. But then comes the question, why is it that this number and order of rock-groups is nowhere to be seen except in the small area of North Devon? No such order and succession of groups is to be seen even in South Devon on the other side of the central Coal-measure trough, and certainly not in Ireland, where the sections across the whole formation are far finer and more numerous,

and exhibit the rocks in a much less disturbed condition, and with much greater clearness than do those of North Devon.

Mr. Etheridge divides the Devonian rocks of north Devon into ten groups, of which he assigns five to the Upper Devonian, three to the middle Devonian, and two to the Lower Devonian. He agrees with me that the lowest of the first five groups, the red sandstones of Pickwell Down, are the upper Old Red Sandstone, and that the lowest of the other five groups (which he calls Lynton Sandstone) is also part of the Old Red Sandstone—he supposes the lower part.

If, however, the traces of plants about Countesbury, east of Lynton, be real, and still more, if the genus Knorria occur there, it is good palæontological evidence in favour of these being Upper Old Red like his Pickwell Down sandstone, from which I have myself collected pieces of *Knorria* north of Braunton.

Independently of the occurrence of plants, I believe these Foreland, Porlock, and Dunster beds to be Upper Old Red Sandstone, both from their resemblance to that of Pickwell Down and Dulverton, and to the Upper Old Red of Ireland.

If, then, we place Mr. Etheridge's groups side by side, thus—

Southern Area.	Northern Area.
5. Pilton and Barnstaple beds.	5. Grey unfossiliferous slate.
4. Braunton beds.	4. Calcareous slates.
3. Croyde beds.	3. Hangman grits.
2. Baggy and Marwood slates.	2. Lynton slates.
1. Pickwell Down sandstones (red).	1. Lynton sandstone (red).

we have at once two sets of five groups, each set showing a base which every body recognizes as exactly similar to some part or other of the genuine Old Red Sandstone, but containing no fossils unless plant fragments, while the four other groups are various grey clay-slates, variously interstratified with sandstones and grits, all containing here and there marine fossils. Are these not the same groups repeated?

There are variations, both lithological and palæontological, in the four upper groups of the two areas, both in latitude and longitude, and fossils are sometimes absent from large parts of the groups. It is also remarkable that in both areas there are, in the lower part of the slaty groups, bands of sandstone or gritstone, variable in colour and character, which contain casts of shells only, and those belonging to Conchifera and Gasteropoda chiefly, such as *Cucullæa*, *Myalina*, *Natica*, &c., &c., while above and below these sandstones, shells of those classes are rare in comparison with Brachiopoda, and other fossils.

It appears to me that these broad facts are considerably in favour of my views, whatever variations may take place in the lithological character of the rocks of the two areas, which are not perhaps materially greater than can be seen to occur in any of the bands of either area, when traced from end to end along the strike, and are certainly not greater than can be seen to occur along the strike of the same beds in Ireland.

Similar variations may, and in Ireland do, take place in the fossils of the same beds, when traced on the strike for a few miles, and would be found in Devon both in length and breadth if the beds had remained horizontal, as they are found in many other formations.

Mr. Etheridge draws a section across the Main Down from north to south, showing the dark "upper slates of Middle Devonian," passing under the red sandstones of his "Pickwell Down" group, where I have supposed them to be faulted against it. He does not, however, mention any place where the red sandstones can actually be seen to lie upon the grey slates. The grey slates can only be seen to dip at the red sandstones, in greater or less proximity to them. There is, I believe no section to be found in the country in which the junction of the rocks is shown with sufficient clearness to be adduced as a proof either for or against the fault. In a "strike fault," where the beds are highly inclined, it is obvious that it would require a good tall cliff right across it to exhibit this proof whichever way it lay.

In Mr. Etheridge's section, at p. 593, however, his lines, if they are to be taken as the true representation of the "lie" of the beds, prove that there must be a dislocation of some kind just where I have supposed one, for there is a considerable thickness of his "upper slates of middle Devonian" on the top of the hill of Whitfield on the north, which are left unaccounted for on the south side of the anticlinal which he introduces under Langley Marsh. These slates ought to come in under the sandstones of the Rhaddon slope, and their absence involves the necessity of supposing a fault of some sort at the foot of that slope. Oddly enough, another palæontological friend some time ago sent me a section across this very neighbourhood to prove to me there was no fault, while the very stratigraphical lines he drew to represent the lie of the beds proved, like Mr. Etheridge's lines, that if the facts were correctly represented, there must be a fault just where I had drawn it, in order to account for the absence of a number of beds on one side of a curve, which appeared on the other side of it.

Of course, in each case, the drawing of these lines merely showed haste in sketching out the ideas of the authors; but I mention these instances to show that the sections are not so much the representation of visible facts as of the ideas of the authors. In the six-inch sections of the Irish Geological Survey, since I have been Director of it, we have inserted in the sections those facts only which were actually to be seen on or near to the line of section, leaving our inferences as to boundaries, faults, &c., to be modified, or corrected, by the discovery of additional facts, or a truer interpretation if necessary.

If that were done for North Devon on sections of large scale, it would be seen that the facts actually visible give no proof anywhere either for or against the fault, which I introduce hypothetically as an inference from the general structure of the country.

It seems to me that the hypothesis, re-stated by Mr. Etheridge, that the Old Red Sandstone, after maintaining a great similarity (in its upper portion especially), through Scotland, England, Wales and Ire-

land, and never showing any marine fossils, suddenly passes into, or takes in, a great thickness of beds of grey slate and sandstone abounding with marine fossils, is a wilder supposition than the other, which supposes the Carboniferous Limestone, that certainly varies so much in its lithological type in passing from Derbyshire through the north of England into Scotland, and shows similar variations, when traced from the north to the south of Ireland, and which everywhere contains marine fossils, makes one more and greater departure from its ordinary type in the extreme S. W. of Ireland and England, and simultaneously exhibits a number of marine fossils differing to a greater or less extent from those of its other area. This difference may be the consequence of its entering another life-province, in which perhaps the depth and temperature of the water, the nature of the bottom, the direction of the currents, and other life-modifying incidents, may have varied from those in the first province.

The Devonian province may have had an unbroken connexion with seas in which Upper Silurian forms formerly lived throughout the time when the Old Red was deposited, and may, therefore, have retained a more antique and Silurian tinge about them, while the Carboniferous Limestone animals may have originated in some other sea which, during the Old Red Sandstone period, may have been subject to other influences, and the species been modified accordingly. On the subsequent reunion of these seas in the Carboniferous period two life-provinces may have thus been produced, separated by as sharp a line perhaps as some of the life-provinces in the seas of the present day are said to be.

I have, however, no wish to dogmatize; I merely wish to lay before you the result of my own examination of this question, which has more or less occupied my attention ever since the year 1851, when I first began to examine the rocks of Cork, in conjunction with my then colleagues of the Irish Survey, and with the occasional assistance of Edward Forbes, whose loss we have had so much reason to regret for the last twelve years.*

POSTSCRIPT NO. II.

April 8th.—Hearing from Professor Huxley that he had just received from Mr. Pengelly a specimen of *Pteraspis* "of a larger size than any species previously known," I wrote to Mr. Pengelly for information respecting its locality. He informs me that it was procured at Old Mills, Looe, Cornwall. The specimen was part of a collection of more than three hundred fossils which he had procured from various points along the coast between the Fowey river and Rame Head, and has mounted

* I have to acknowledge one error which Mr. Etheridge has corrected. The shell in the Carboniferous Limestone formerly called *Producta analoga*, was called so from its analogy to the *Producta depressa* of the Silurian rocks. Seeing that now it is reckoned a mere variety of *Strophomena rhomboidalis*, I somehow had got the notion that the species called *depressa* had been recognized as another variety. In this I find I was mistaken. Perhaps, however, the mistake may be prophetic.

and labelled in his own museum. They were at first all believed to be of ichthyic origin, till Professor M'Coy and Mr. Carter, of Cambridge, referred them to sponges of the genus *Steganodictyum*. On being shown this collection the other day, the Rev. W. S. Symonds decided this specimen to belong to *Pteraspis;* and on its being referred to Professor Huxley, the determination was confirmed.

The *Phyllolepis concentricus* and the other fish previously found by Mr. Pengelly were from the same beds.

This appears to me to be the strongest presumptive evidence yet derived from fossils in favour of those beds being of contemporaneous origin with the Old Red Sandstone. Nevertheless, it is not conclusive proof. It is obvious that the occurrence in the Devonian rocks of species of fossil fish belonging to the same genera as those of the Old Red Sandstone no more proves the Devonian beds to have been contemporaneous with the Old Red than the occurrence of species of tribolites, of the same genera as those in the Silurian rocks, prove the Devonian rocks to be contemporaneous with the Silurian.

If more fish of the same *species* as those of the Old Red Sandstone be ultimately found in the Devonian beds (such as the *Phyllolepis concentricus*) the fossil evidence in favour of the contemporaneity of the deposits merely attains to the same strength as that derived from the occurrence of undoubted Carboniferous limestone species in favour of the contemporaneity of the Devonian beds and the Carboniferous limestone.

Species of vertebrata may indeed have had a shorter duration than those of the lower parts of the animal kingdom, and thus carry with them the greatest weight in questions of geological time; still it appears to me that there is nothing in the fossil contents of the Devonian beds which is conclusive against the idea of their occupying a position between the top of the Old Red Sandstone and the base of the Coal-measures.

I have also just been indebted to Professor W. King, of Galway, for the sight of a paper, by Professor James Hall, of New York, published in the "Proceedings of the Phil. Society of Philadelphia" for the year 1866, and entitled "Observations on some Species of *Spirifera*." This contains an extract from the unpublished fourth volume of the "Palæontology of New York." In this paper the gradual variation of many so-called species into each other is remarked upon. He also insists strongly on the gradual lithological change that takes place in the Devonian beds and the Carboniferous beds as they are traced from one locality to another in the State of New York, and the corresponding changes in the species of fossils included in them. The following passage strikes me as a curious coincidence with my own views on this matter:—

"It here becomes a matter of great interest to decide what shall constitute the *Fauna Devonian* and what may be regarded as the *Fauna Carboniferous*. Looking at the great number of *Producta* . . . in the central and western portion of the State, they alone would give a

Carboniferous aspect to the Fauna; but when we find *Spirifera disjuncta* and other fossils of acknowledged Devonian age, we instinctively allow less than the due importance to the Carboniferous evidence. Nevertheless we are forced to admit, even within the State of New York, a gradual diminution of the Devonian types, and an augmentation of the Carboniferous types in the same beds as we go westward; and finally we have every reason to believe that in those sedimentary formations, between the Hamilton group and the Coal-measures on the east, and between the same group and the Burlington (Carboniferous) limestone on the west, the Devonian aspect of the Fauna on the one hand, and its Carboniferous aspect on the other, are due in a great degree to geographical and physical conditions, and not to difference in age or chronological sequence of the beds containing the fossils."

If to this we add, that even among the Devonian fossils many so-called species may be merely *varieties* of the Carboniferous species, I think that few geologists can hesitate to agree with me that the Devonian problem requires re-examination at all events.

I hope that no expression of mine in this or previous papers may have prejudiced the mind of any one against undertaking this re-examination in a spirit of calm but searching inquiry.

VII.—Illustrations of the Extinct Volcanoes of the Eifel. By Major-General Nelson, R. E.

[Exhibited January 8, 1868.]

The sketches accompanying this brief notice of the Eifel district are illustrative of certain marked points in the western extremity of the great belt of extinct volcanoes traversing the centre of Germany, from near Aix-la-Chapelle and Treves on the west, through Hesse Cassel, along the northern mountain ranges of Bohemia, to near Breslau, in the heart of Silesia. This belt may be about 450 miles in length, and, at a rough average, about 30 miles in breadth. It would be an interesting problem to determine if any or what relations exist between this zone and the like districts in Auvergne, Scotland, and Ireland.

The above-mentioned "western extremity" is characterized by its central position, the wild district of the Eifel, a somewhat elevated plateau, about 35 miles long by perhaps 25 wide, sloping from west to east, and marked at all points by volcanic action, as evidenced by small, low basaltic or trachytic cones, more or less connected by irregular deposits and hills of felspathic tufa, and by spaces covered by pumice gravel and ordinary volcanic sand.

These exhibitions of volcanic agency vary a good deal in character, from mere explosions* through the local clay-slate and sandstone to

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* See Lyell's "Manual," 4th edition.

cases of incipient fusion, for complete fusion, as shown in glassy lava, has nowhere as yet been discovered. There has, however, been intense heat in action, as shown by the contents of the Leileskop, by the appearance of the junction of the trachyte and slate at Olbruch, and by the highly scoriaceous character of such volcanoes as the Hoch Simmer (Fig. B, C), the Nickenicher Sattel (Fig. A), the Roderberg (Fig. H), &c., &c.

The felspathic portions of the Eifel consist chiefly of a muddy tufa, or "trass"—a true moya—sometimes forming distinct hills, like the Plaidter Humrich and the Saftiger Humrich; sometimes irregular deposits on the general plateau, as at Bell; or else filling the bottom of a valley, as in the neighbouring Brohl-thal, from whence the so-called Dutch Terrass (Trass) has long been taken in considerable quantities as an hydraulic cement. As Hibbert* observes, this last seems to have proceeded from the felspathic volcano, the Summerfeld, at the head of the valley.

The more perfect display of Trachyte is to be found in the central parts of the Siebengebirge, especially at the Drachenfels (Fig. D), and the adjacent hill, the Wolkenberg (Fig. E). In the former there is much of a whitish kind, bearing apparently much the same relation to granite that the Devonian Trachytes do to the older porphyries; it is at some points so soft that fine well-formed crystals of felspar may be detached by the finger.† In no place, however, is the volcanic origin of the Trachyte so well shown as in the Wolkenberg (Fig. F), where the choked-up vents can be now traced by their concentric coats and circles on the surface of the hill, or shown by the vertical sections given in the face of the quarry.

The varieties of Basalt in or near the Eifel are numerous; we find abundantly the characteristic jointed columns, as at Unkel (Fig. G), Minderberg (Fig. F), Rolandseck, &c.; perfectly well stratified deposits, as at Ober Cassel, &c.; marine Basalt, many feet in thickness, as at Mennig‡ and Eich in the Eifel, and heaps of mere scoria. The most characteristic mineral of the Basalts is Olivine; it is of frequent occurrence, especially in the columnar varieties.

In connexion with these small volcanoes should be mentioned the numerous and remarkable little lakes, formed by the water collected in many of their craters, as at the Moselberg, where there are three in the three vents, three more on a low level at Schalkenmeeren, near Daun; at the Pulver Maar, or the large one of the Laacher See.§

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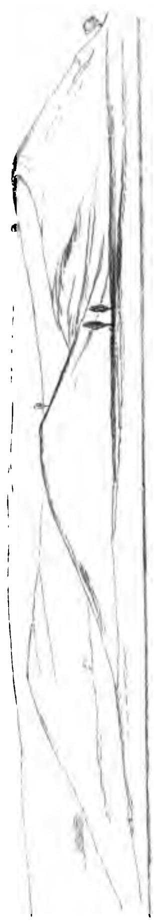
* See Dr. Hibbert's most interesting volume on the Eifel.

† Compact as these Trachytes are in general when newly raised, they decompose too rapidly to be good for grand architectural purposes. Witness the decay of the finer ornamental portions of the Cathedral at Cologne, and that at Exeter, apparently from the local trachyte quarries.

‡ Worked by the Romans for millstones. The first thing I saw at the Cape, in 1836, was a dozen of them outside the Castle, just as I landed.

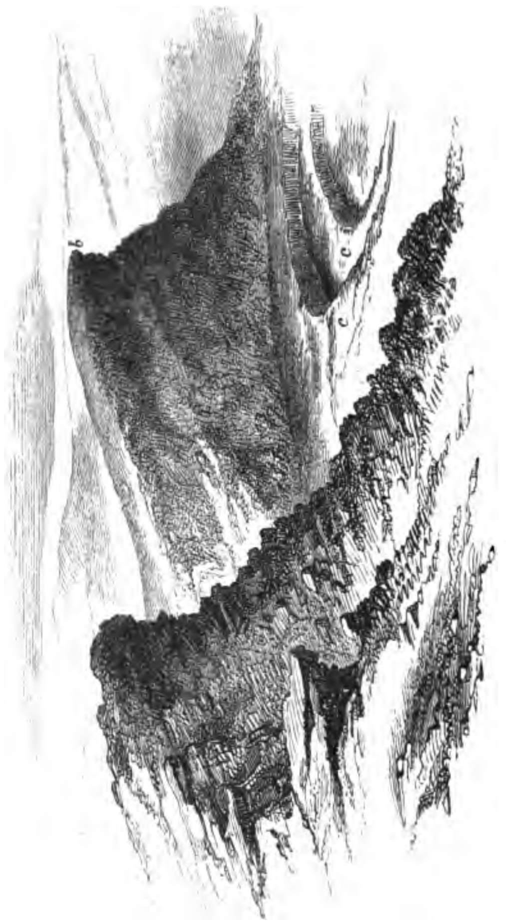
§ One of these has a sufficient spring and surplus to turn a mill; it contains pike; the other two are stationary, and afford only fresh-water crayfish.



A.—The Niehenicher Sattel.

B.—The Hoch Simmer.

TO ILLUSTRATE MAJOR-GENERAL NELSON'S PAPER ON EXTINCT VOLCANOES OF THE EIFEL.

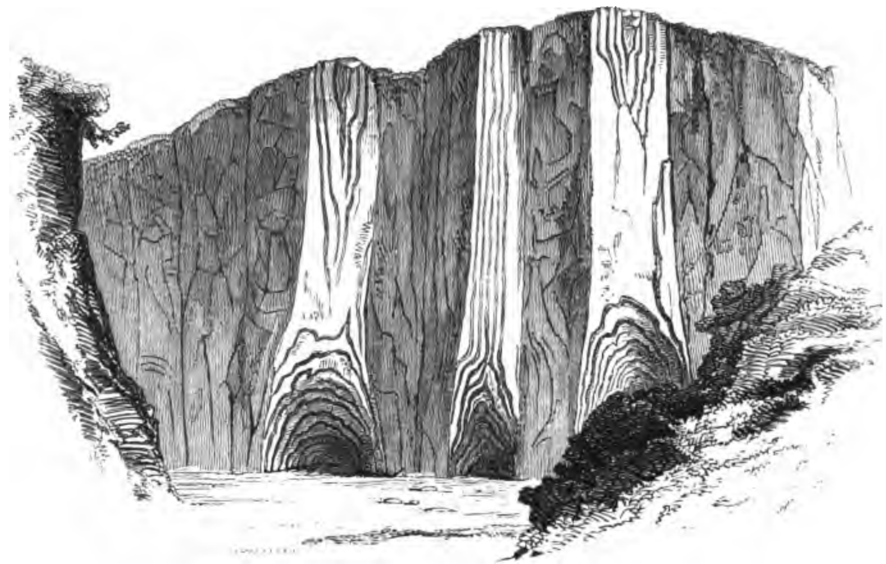


C.—The Cinders Crags of the Hoch Simmer.

To illustrate Major-General Nelson's Paper on Extinct Volcanoes of the Eifel

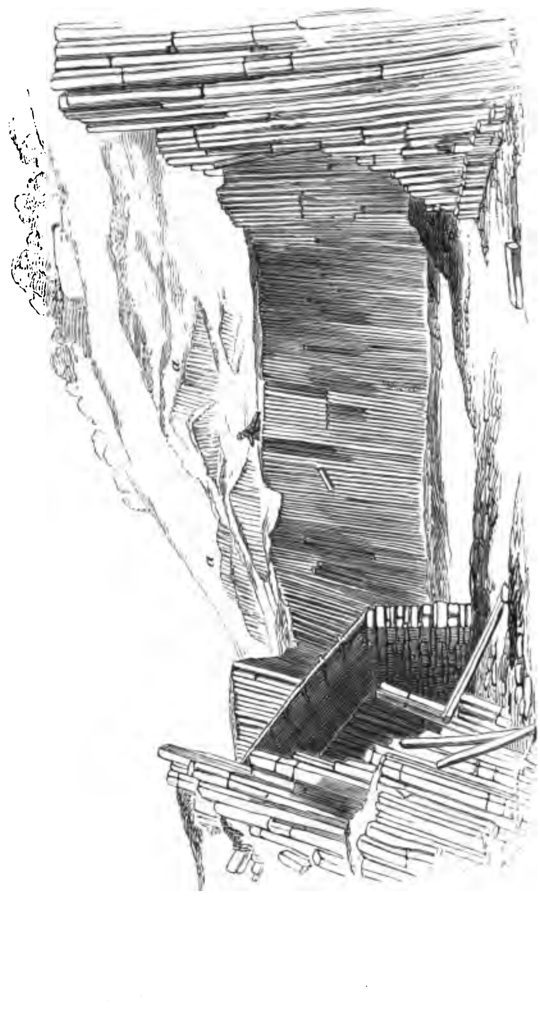
D.—The Drachenfels.

TO ILLUSTRATE MAJOR-GENERAL NELSON'S PAPER ON EXTINCT VOLCANOES OF THE EIFEL.



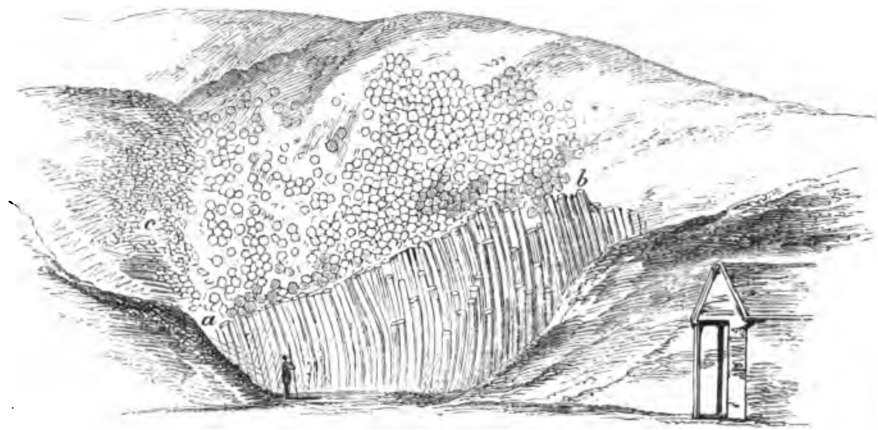
E.—The Wolkenberg.

To illustrate Major-General Nelson's Paper on Extinct Volcanoes of the Eifel.



F.—The Minderberg.

To illustrate Major-General Nelson's Paper on Extinct Volcanoes of the Eifel.



G.—Opposite Unkel.

To illustrate Major-General Nelson's Paper on Extinct Volcanoes of the Eifel.

H.—The Roderberg and Rolandseck.

To illustrate Major-General Nelson's Paper on Extinct Volcanoes of the Eifel.

In the Siebengebirge, the cross filons of basalt and wood-coal in the Trachytic conglomerate near Wintermühlen, and near Königswinter, show the relative ages as far as Trachyte is concerned.

The Löwenberg (one of the Siebengebirge) and the neighbouring Breiberg show much Doloritic Basalt.

DESCRIPTION OF THE SKETCHES.

A.—The Nickenicher Sattel, a Crater of Basaltic Scoria, about 900 yards long by 500 broad, situated a few miles west of Andernach.

B.—The Hoch Simmer, a Crater of Basaltic Scoria, as seen from the Hoch Stein.

C.—The Cinder Crags (*b*) of the above, as seen from *a*. The terraces (*cc*) are artificial, having been formed for agricultural purposes.

D.—Sub-columnar structure of the *Drachenfels* Trachyte, as also shown in the neighbouring hill, the Wolkenberg.

a, *a*, The local Grauwacke; *b*, *b*, Trachytic conglomerate covering *a*.
c, *c*, The Trachyte.

E.—Vents in the Trachytic Volcano of the Wolkenberg adjoining the Drachenfels, which have become choked by concentric coatings.

F.—Basalt Quarry of the Minderberg, near Linz. *a*, *a*, Outcrops of columns in the hill side.

G.—Basalt Quarry, opposite Unkel (as it was seen in November, 1834).

The columns above *ab* are more or less horizontal; their ends are flush with the surface of the bank. The pillars at *c* are very imperfect, much broken, and greatly decomposed.

H.—The Roderberg—A Crater of Basaltic Scoria, coming up through slate rock below—as seen from the Drachenfels.

a, Rolandseck—A Cone of Columnar Basalt bursting through the side of the Roderberg.
b, Schloss Olbrach, on a trachytic cone.
c, The Hohe Acht.
d, The Roderberg farm.
bc is nearly the northern ridge of the Eifel.

VIII.—Notes on the Kammerbuhl, an extinct Volcano in Bohemia. By the Rev. H. Lloyd, D. D., Provost of Trinity College.

[Read January 8, 1868.]

The "Kammerbuhl" is a diminutive extinct volcano, situated about two miles to the east of Franzensbad, in Bohemia. The word "buhl," in old German, signifies a "little hill;" and the prefix of the name is derived from the crown-lands within which it lies. It is, perhaps, the smallest volcanic hill in Europe; and it has attracted much attention, not only on account of its remarkable form, but also because of its complete isolation, there being no other traces of volcanic agency in the district immediately surrounding. Having had an opportunity of fully exploring it eighteen years ago, and having twice revisited it during the

last summer, I have put on paper a brief description, in the hope that it may be of some interest to the Society. In any case, the small collection of specimens, sent herewith, may be of use in the Geological Museum, as they are characteristic, and have been selected with care.

The Kammerbuhl is a small rounded mass, of very regular form, at least as seen on approaching it from the east. It is situated upon a long and low ridge, which appears to have once been the southern boundary of an extensive lake, whose ancient bed now forms the remarkable moor-land to the west of Franzensbad. This lake appears to have been bounded by the "Kammerwald" (a low chain of wooded hills) on the western side, and by the high ground on the slope of which the town of Franzensbad is situated, to the east and north. The subjacent rock is mica-slate, containing abundant veins of quartz. I was unfortunately unprovided with any instrument for the measurement of altitudes, but I should estimate the height of the hill above the surrounding ground at between 50 and 60 feet.

The hill is covered with a short grass; and a very thin coating of *humus* separates the surface from the cindery mass, of which it is mainly composed. A few scattered juniper trees form the only remaining vegetation. At the top there is a hollow cup, 50 feet wide, and 7 feet deep, somewhat similar in its appearance to the mouths of the craters which are still distinctly traceable in several of the volcanic cones of Auvergne. But it is said to have been made artificially.

There is a large excavation on the southern side of the hill, called the "Dwarf's Hole," from the belief of the peasants that small men—or, as they would be called in Ireland, "fairies"—have been occasionally seen there at midnight. It is, however, nothing more than an artificial excavation formed by the extraction of road materials. As it is 30 feet in height at the side nearest the summit, it enables the observer to examine with ease the structure of the hill, which is composed, as has been said, mainly of volcanic cinders and their comminuted fragments. These are disposed in layers of various degrees of fineness, and of various colours—black, red, and yellow. No fewer than forty such layers may be traced; and it may be observed that the contour of those near the surface is parallel to that of the surface itself, while they become flattened, and approach to horizontality, as they are lower. This fact which (as far as I am aware) has not been noticed before, affords conclusive proof that the elevation of the hill was not caused by an *uplifting* of the strata.

The only portion of the hill which is composed of solid rock is at the western side. Here there are large irregular masses of basalt, the remains of a lava-stream which broke out from an opening near the summit at that side, and descended to the bottom. The greater part of this mass has been long since carried away for building material; the Roman tower in the neighbouring town of Eger is entirely constructed of it. This basalt is of a greyish-black colour, and fine-grained, except near the surface, where it passes into the state of porous lava. The

specific gravity of the former is 3·23. It contains *olivine* and *magnetic iron* in grains.

Besides basalt, fragments of *mica-slate* and of *quartz*, both much altered by the action of heat, are to be found among the ejected masses. The mica-slate is of a deep red colour, and soft and friable, like the altered clay-slate which is familiar to us in our domestic fireplaces. The quartz is porous, resembling pumice, and some fragments have been found so light as to float on water. These fragments of quartz and mica-slate sometimes form the nucleus of basaltic masses of various sizes, called "bombs" or "tears." Bombs are sometimes also found consisting of basalt alone; but they are rare.

Besides *olivine* and *magnetic iron*, there have been also found, in connexion with the basalt, *obsidian*, *basaltic hornblende*, and some of the *zeolites*.

From this enumeration of the mineral contents of the Kammerbuhl, it is manifest that it was a volcano. From the arrangement of its materials it is evident that its elevation was due to the successive deposits of ejected cinders, which were disposed with some regularity around its vent; and that the last effort of the internal forces was the ejection of the lava mass on the western side. That the elevation was not the result of an *uplifting* is plain from the materials of which it is composed, which were all *ejected* before they were *deposited;* as also from the form of the successive layers already noticed. And that the activity of the internal forces ended with the ejection of the lava stream is manifest from its position with respect to the other products of the volcano, the basalt overlying the other ejected materials.

I have thought that this brief notice might be interesting to the Society, on account not only of the peculiar position of the Kammerbuhl, but also because its nature has been the subject of much discussion among German naturalists. It was written about by Goëthe, who visited it twice; by Leohnard; by Goldfuss and Bischoff; by Berzelius; by the two Cottas; by Noggerath, and by Reuss.* By some of these writers—as by Goldfuss and Bischoff—it was supposed to be a "pseudo-volcano," and to have owed its origin to a bed of brown coal which took fire beneath the surface. But Berzelius, and after him all the more recent writers—with the exception of Von Sternberg, who has done so much to explore it—allow it to be an extinct volcano. In fact, no one who has ever visited the Eifel, or the extinct volcanoes of Auvergne, can question the identity; and the same thing is convincingly proved by its contents, which are all, without exception, of volcanic origin. The only question seems to be whether the eruption took place under water. That such was the case was the belief of the elder Cotta, who has given the first detailed account of it. He supposes an earth-cleft to have been

* A clear summary of the views of these several writers has been given by Dr. Palliardi, one of the resident physicians at Franzensbad, in a descriptive account of the Kammerbuhl.

formed by the eruption, and the water of the lake under which it took place to have been thus drained off. This supposition appears to have been made in order to account for the spreading of the cinders in one direction; but, as has been observed by Noggerath, this may have been simply the effect of wind. On the whole, there seems to be nothing but its isolation to distinguish this hill from other well-known effects of volcanic action.

There is a very remarkable lacustrine deposit in its immediate vicinity, to which I have already referred when describing the situation of the Kammerbuhl. The *moor soil*, which appears to occupy a large portion of the bed of the ancient lake there referred to, is 9 or 10 feet deep, and lies, like our peat, upon what appears to be a marly loam. It is quite black, and soft and unctuous to the touch. It appears to be almost wholly composed of leaves, and to be destitute of vegetable fibre. This moor loam is the substance employed in the so-called "mud-baths" of this neighbourhood. For this purpose it is excavated, and left exposed to the air for a year before it is employed; it is then carried to the baths, where it is triturated, and formed into a black paste with water.

It may be that this vegetable mass is the source of the carbonic acid which pervades all the mineral springs of the vicinity, and which even makes its way in a free state to the surface in more than one locality about Franzensbad. The gas is there employed for hygienic purposes. A cavity is made in the ground in the vicinity of the spring, about three feet in depth, and is filled with the gas; and in this cavity, which is covered by a suitable building, the bathers sit from a quarter to half an hour at a time, their heads being above the level of the gas, which flows off at the top of the excavation. The effect on the skin is stimulant, and it is said to be of much service in cases of paralysis or partial numbness.

IX.—Additional Notice of the Zeolites of Western India. By the Rev. Samuel Haughton, M. D., F. R. S.

[Read February 12, 1868.]

In June, 1866, I laid before the Society an account of some Zeolites from Western India, presented by General Montgomery, Bombay Army, to the Museum of Trinity College, including the following species:—*Apophyllite*, *Stilbite*, *Hypostilbite*, and *Harringtonite*. Since that time I have received from Dr. Thomas Oldham, Director-General of the Geological Survey of India, my predecessor in the chair of Geology in Dublin, a valuable collection of Zeolites from the same part of India; and also some fine and rare specimens from the neighbourhood of Boreghaut, collected by Mr. Going, C. E., Madras Railway, and others from Mr. Montagu H. Ormsby, C. E., of the Indian Geological Survey.

I am enabled, from an examination of these specimens, to complete the description of the Bombay *Apophyllite* and *Stilbite*, and to add the

analyses of two additional Zeolites to the Indian list, viz., *Scole* and *Dysclasite*.

No. 1.—Apophyllite.

The angles measured in this mineral were as follows:—

$$(1) \quad (\infty . \infty . c)\ (1 . 1 . c) = 120^\circ \cdot 20'$$
$$(2) \quad (1 . 1 . c)\ (-1 . 1 . c) = 103^\circ \cdot 30.$$

From the first of these angles, we find—

$$\cos(120^\circ\ 20') = \frac{1}{\sqrt{2c^2+1}}$$

$$c = 1{\cdot}208.$$

From the second of these angles, we find—

$$\cos(103^\circ\ 30') = \frac{1}{2c^2+1}$$

$$c = 1{\cdot}281.$$

The mean of the preceding values of c is 1·2445.
The value given by Dana for the ratio of the axes is 1·2515.

No. 2.—Stilbite.

I have already published analyses of two Stilbites from Western India, from the Nerbudha Valley, and from the neighbourhood of Poona. The present Stilbite was given to me by Mr. Going, C. E., and was found near Boreghaut. It occurs in "rice grain" crystals, covering large surfaces of trap rock, and differs in appearance from those already described. The following Table gives the chemical composition of all three specimens:—

Analyses of Stilbite from Western India.

	Nerbudha.	Poona.	Boreghaut.
Silica,	56·59	58·20	57·00
Alumina,	15·35	15·60	17·10
Lime,	5·88	8·07	7·95
Magnesia,	0·82	none.	trace.
Potash,	0·89	0·92	} 0·32
Soda,	1·45	0·49	
Water,	17·48	18·00	18·03
Total,	98·46	101·28	100·40

The oxygen ratios and mineral formula of the Boreghaut specimen are as follows:—

Boreghaut Stilbite.

	Oxygen.	Atoms.	Atoms.
Silica,	29·595	9·865	4
Alumina,	7·992	2·664	1
Lime,	2·260	2·341	1
Soda,	0·081		
Water,	16·000	16·000	6

$$RO, SiO_3 + Al_2O_3, 3SiO_3 + 6HO.$$

No. 3.—Scolezite, or Lime Needlestone.

This mineral is associated with Apophyllite near Poona, and is found in bundles of long needle-shaped crystals, semi-transparent. Its chemical analysis gives the following results:—

Scolezite—Poona.

	Per Cent.	Oxygen.	Atoms.	Atoms.
Silica,	45·90	23·832	7·94	2
Alumina,	26·10	12·198	4·06	1
Lime,	14·71	4·181	4·20	1
Soda,	0·09	0·023		
Water,	13·68	12·159	12·16	3
Total,	100·48			

$$RO, SiO_3 + Al_2O_3, SiO_3 + 3HO.$$

This is the well-known formula of the *Needlestones*, which are called *Natrolite* when the protoxide base is soda, and *Scolezite* when the protoxide base is lime.

No. 4.—Dysclasite (Okenite).

This mineral is found at Poona, in cavities of the amygdaloidal Trap, in nodular masses, formed of smaller spheroidal concretions of radiated structure, and is characterized by extraordinary toughness, from which its name was originally derived. Its chemical analysis and mineral formula are as follows:—

Dysclasite—Poona.

	Percentage.	Oxygen.	Atoms.
Silica,	54·24	28·160	4
Alumina,	none.		
Lime,	27·44	7·801	3
Soda,	0·07	0·018	
Water,	17·04	15·147	6
Total,	98·79		

Hence the formula of the mineral is

$$3CaO_1\ 4SiO_3 + 6HO.$$

X.—On the Anatomical and Ethnological Characters of the Skull of an Aboriginal Inhabitant of Chatham Island. By Alexander Macalister, L. R. C. S., Demonstrator of Anatomy, R. C. S., &c.

[Read February 12, 1868.]

The Chatham Islands constitute a small group of basaltic and trappean mountainous islets, placed between 43° 40′ and 45° 20′ south latitude, and 176° and 177° 30′ west longitude. They are about 386 miles east of New Zealand, and the group consists of two large and many small islands. They were discovered in 1791, by Lieutenant Broughton, of H. M. S. Chatham, and the largest of the cluster (Warekauri) was named by him after his vessel; the second largest, at the same time, by a natural association, received the name of Pitt Island. The former of these islands measures about 90 miles in circumference; the latter is not quite so large. The Flora is said to approximate to that of New Zealand, and the Fauna presents the same features. When discovered, the largest islands of the group were inhabited by a race of savages, described as being quite distinct from the Maori family, darker in complexion, and known by the Maories as *Blafello*, a corruption of the English words black fellow, and more closely resembling the inhabitants of New Holland than the true Malays. This tribe was computed to number about 1200, and they held undisturbed possession of the land until about the year 1830, when they were attacked by a predatory band of Maories, and became quite subjugated. Their original habits became assimilated to those of their conquerors, and the Maori dialect of the Polynesian language has superseded their own—a fact indicated by the names of all parts of the islands, and of its vegetable productions. According to the most recent information, this aboriginal tribe has nearly passed into extinction, and consequently all relics and traces of them indicative of their true ethnological position become of increasing value. The cranium, which forms the subject of this memoir, was presented to the Museum of Trinity College, Dublin, by Dr. Lingen, of Hereford, through Dr. Stokes, of this city, and as the anatomical characters exhibited by it seem of interest, I have thought that its description might be worthy of record. This skull is apparently unaltered by artificial compression; the bones are thick and dense; the compact layers thicker than ordinary. It was evidently the cranium of an adult, and most probably that of a male in middle life; the sutural lines are distinctly visible externally, but the coronal and sagittal are obliterated internally. The *norma lateralis* shows a distinctly prognathous outline, and a very low facial angle; the various processes and ridges are strong and rather coarse; when viewed from above, it appears a little flattened anteriorly, the line from the anterior border of the maxillary angle of the molar on one side passing nearly in front of the nasal prominence to the opposite side.

The following measurements I have made of the skull; and in order to illustrate their bearings I have placed beside them, for the purpose

of comparison, the corresponding measurements of the skulls of a New Zealander, a Papuan of New Guinea, a Negro, and an Irishman.*

	Chatham.	Negro.	Papuan.	Maori.	Irish.
Cephalic index,	·714	·710	722	·712	·722
Greatest length,	7·0	6·9	7·2	7·3	7·2
" breadth,	5·0	4·9	5·2	5·2	5·2
Vertical height,	5·6	5 5	5·6	5·9	5·3
Internal length from ¾th inch above crista galli to 1 inch above torcular Herophili,	66	61	..	..	62
Thickness of frontal bone,	4	4	..	..	2
Length of spheno-parietal suture,	3	3·5	4	..	6
" foramen magnum,	1·4	1·3	1·5	..	1·3
Breadth of " "	1 2	·95	1·3	..	1·1
Width of palatine arch across last molar tooth,	2·6	2·8	2·7	..	1·5
Distance between tips of mastoid processes,	4·0	4·0	4·5	..	4·0
From incisor alveolus to palatine spine,	2·0	2·15	2·5	..	1·8
From occipital protuberance to edge of foramen magnum,	2·1	1·8	..	..	2·0
From posterior border of one zygoma to its fellow,	5·5	5 0	5·5	..	4·7
Basicranial axis,	..	2·7	..	..	2·2
Anterior inter-lacrymal diameter,	1·0	1·2	1·4	..	1·3
Length of palate plate of palate bone,	·5	·5		..	4·5
Length of zygomatic arch,	2·2	2·0	2·6	..	2·4
Transverse arc from mastoid to mastoid,	14·5	..	14·7	14·0	14·0
Longitudinal arc from supraorbital ridge,	11·9	12·6	14·7	15·1	13·0
Circumference an inch above fronto-nasal suture,	1·92	19·7	20·1	20·7	20·5

The cranium is distinctly phænozygous, as, when viewed from above, distinct space intervenes between the zygomatic arches and the temporal fossæ; and as the cephalic index is ·714, we may regard it as an example of the mecocephalic group of crania; the very low facial angle indicates the prognathous arrangement of the face bones, and the coronal suture is placed vertically over the anterior lip of the foramen magnum.

When the bones are examined in detail, the following characters are seen:—The frontal exhibits several vascular holes, 1⅛ inch above, and to the right of the supra-orbital ridge; there are two supra-orbital foramina on the right side, and but one complete perforation on the left, with an internal diplic foramen to its right; a supra-trochleator groove and a trochlear fossa exist on each side; the frontal sinus is moderate in size; the anterior internal orbital foramen is proper to the

* All the measurements in tenths of an inch.

frontal, while the posterior is common to that bone and the os planum of the ethmoid. A few small Wormian bones exist in the right coronal suture, and a strong mesial frontal crest is present internally, commencing above a very small foramen cæcum. The fronto-presphenoidal suture is very irregular and denticulated, and external to the point of the lesser wing the superior surface of the greater wing projects on both sides through the orbital plate of the frontal bone, forming one island on the left and three or four on the right side in the floor of the anterior cranial fossa; the spheno-parietal suture is extremely short; the left parietal presents depressions internal to and in front of the eminence of that bone which is permanent; the inferior posterior angle has several Wormian bones in contact with it intervening between the occipital, mastoid, and parietal bones. The lambdoidal suture is open, the left parietal has a sulcus externally, but no true parietal foramen. The condyloid eminences of the occipital are large, and the sinus marks small; the mastoid process is small; the zygomatic process stout and strong; the internal auditory meatus short and wide, and the aqueduct of Fallopius double at its origin. The sphenoidal body presents a narrow ethmoidal spine; no middle clinoid process; the external pterygoid plate is narrow, and in its outer side there is as deep fossa, sheltered by a third pterygoid plate, which forms an inferior boundary to the pterygo-maxillary fossa, and which comes in contact below with the outer surface of the pyramidal process of the palate bone. The optic foramen of the right side looks upward and backward, and the root of the lesser wing beneath it is projected into a shelflike process from the right edge of the olivary process to the anterior clinoid. The lingulæ sphenoidalia are long, and nearly join the apices of the petrous bones arching over the vidian foramen. The orbital plate of the palate is extremely small, and can scarcely be seen in the floor of the orbit. The vertical plate of this bone extends far forward; the sphenoidal process of the palate bone does not join the turbinated bone of Bertin; the palate is very deep; and although the alveoli are broken, yet enough remains to show that all the teeth were developed; the infra-orbital canal is lower than usual, being at least half an inch below the lower margin of the orbit.

When we sum up all these features, we can see clearly that the anatomical features of this cranium evidently associate it with those of the Melanesian group—thus bearing out the observations of Dieffenbach and Broughton upon this race, that the affinities of the aboriginal races were most close to the Australian tribes.

XI.—Report of Council.

[Read at the Anniversary Meeting, on Wednesday, February 12, 1868.]

In presenting the Fourth Annual Report of the Royal Geological Society of Ireland the Council have to record but few changes within their term of office. The proceedings during the past year have been of marked interest, and the ranks of fellowships have not diminished in number.

Since our last annual meeting eight new Fellows have been enrolled, and among these your Council have pleasure in numbering Mr. W. H. Baily, whose labours in Palæontology have, on former occasions, enriched the pages of our Journal.

We have lost one of our number by the hand of death, Mr. Markham Brown, and four have resigned the Fellowship of the Society. In one of these, Mr. William B. Brownrigg, we have lost an active and valued member of Council, and a contributor to our Journal. Mr. Brownrigg was one of the first to bring to light the singular vertebrate treasures of the Kilkenny coal-fields, and his resignation, owing to ill health, has been a source of regret.

The financial position of the Society is encouraging; for, although the income for the past year appears somewhat smaller than that of the year before, yet this can easily be accounted for by the fact that the receipts for 1866 included a large number of outstanding subscriptions which had fallen into arrear. The appended statement of the assets and liabilities shows that, although there are some heavy bills due by the Society, yet upon the whole our position is favourable.

The meetings of the Society have been generally well attended, and many valuable papers have been read, which will render the forthcoming number of the Journal at least not inferior in interest to any of its predecessors.

At our first meeting Mr. Good communicated an interesting fact to the Society, namely, the finding of a large boulder of red granite, similar to that of the Mourne Mountains, on the slope of a submarine valley in the Irish Sea.

Mr. Jukes also laid before the Society the results of his researches on the true subdivisions of the carboniferous limestones of the central plain of Ireland. In this paper he showed the singular change of character which the rocks of this formation exhibit when traced from south to north, and the relations which it bears to the Old Red Sandstone, indicating that the period of the deposition of the carboniferous limestone was one during which the preexisting Old Red Sandstone dry land was gradually being depressed, commencing probably from the south-west. He likewise called attention to the fact that sandstone beds may be interstratified with the true carboniferous limestone, as seen in the vicinity of Granard.

Mr. Andrews read a paper on "Oyster Deposits in the neighbourhood of Kenmare," showing that the beds of oystershells, regarded by some as recent, were not accumulated in recent times, and by human agency, but were truly fossil.

A notice was also read by Mr. Gahan of a columnar structure, observed in mortar; and at the same meeting a letter was read from Mr. E. Bagot, detailing the description of a meteor seen in South Australia.

At the May meeting a long and interesting paper, on the "Antiquity of Man," was read by Mr. J. Scott Moore, in which the great antiquity of the human race was defended, and the hypothesis of separate originals for the various divisions of mankind maintained.

Mr. Harte likewise read a valuable and extensive paper, detailing his investigations of the "Post-tertiary Geology of Donegal," with especial reference to the phenomena of glacial action, as exhibited in that county. In this paper he proposed the theory of the dispersion of ice agencies from dominant mountains in opposition to the theory of supposed ice sheets covering extensive surfaces.

At our November meeting Mr. Jukes brought before the Society a paper upon a subject of great present interest, namely, "Notes on the Structure of South Devon and part of Cornwall, and Remarks upon the true relations of the Old Red Sandstone to the Devonian Formation." Mr. Jukes showed that the rocks of the south-west of Ireland afforded the clue to the correct rendering of the South Devon formation, and adduced many facts and observations, stratigraphical and palæontological, to prove that the Devonshire slates were in reality of a date posterior to the true Old Red Sandstone.

At our last meeting the Rev. Humphrey Lloyd, D. D., Provost of Trinity College, communicated a description of a small extinct volcano in Bohemia—the Kammerbuhl; and the Reverend Professor Haughton exhibited before the Society a series of drawings, of extreme value, illustrating the geology of the volcanic district of the Eifel. These sketches were made by Lieutenant-General Nelson, and by him kindly placed at the disposal of the Society.

During the past year the Rev. Humphrey Lloyd, our late President, was elevated to the Provostship of Trinity College, and upon this occasion your Council transmitted to him a letter of congratulation and thanks for the many favours which he had conferred upon our Society in time past. This letter, and the reply of the Provost, are published in the Journal of our Proceedings of the past year.

The removal of Dr. Lloyd from his former rooms in College would have rendered it necessary for your Council to seek for other accommodation for their meetings, as from the time that your Society first met in Trinity College, in 1847, we have had the use of a room in Dr. Lloyd's house, as our council-room and library. Your Council have, however, to return thanks to the Rev. J. A. Malet, Senior Fellow, T. C. D., for his kindness in continuing to the Society the use of the apartment.

TREASURER'S STATEMENT.

The financial state of the Society for the year 1867, although not apparently presenting so favourable an account as that of the preceding year, still maintains a good position, the difference arising between the subscriptions received during the year 1867 of £18 15*s*., being chiefly from arrears due in 1865, paid into the credit of the account of 1866.

£27 12*s*. have, during the year 1867, been invested in New 3 per Cent. stock, increasing the total in that fund to £206 18*s*. 1*d*.

A further investment has been made, which will appear in the account for the year 1868, and which makes the stock now £234 14*s*. 7*d*.

There is still an outstanding balance due to Mr. Gill for printing of £76; but our accounts to the 31st December, 1867, show a balance to be carried forward to 1868 to the credit of the Society of £10 15*s*. 8*d*.

Property to the amount of £200, in books, maps, and charts, have been valued.

In the Appendix will be found, as usual:—

I. A List of Fellows now on the books of the Society.
II. " " gained and lost during the year.
III. " Donations received during the year.
IV. " Societies and Institutions to whom a Copy of the "Journal" is regularly forwarded.
V. An Abstract of the Treasurer's Account for the year 1867.

APPENDIX TO ANNUAL REPORT.

No. I.

LIST OF FELLOWS, CORRECTED TO JANUARY 31, 1868.

Fellows are requested to correct errors in this List, by letter to the Hon. Secretaries, 35, Trinity College, Dublin; or to the Assistant Secretary.

OFFICERS OF THE SOCIETY FOR THE YEAR 1868–69.

PRESIDENT.—The Earl of Enniskillen, F. R. S.

VICE-PRESIDENTS.—Robert Callwell, Esq.; J. B. Jukes, M. A., F. R. S.; Colonel Meadows Taylor, M. R. I. A.; Sir Richard Griffith, Bart., LL. D., F. G. S.; Sir Robert Kane, M. R. I. A.

TREASURERS.—William Andrews, Esq., M. R. I. A.; Samuel Downing, LL. D.

SECRETARIES.—Rev. S. Haughton, M. D., F. R. S., F. T. C. D.; A. Macalister, Esq.

COUNCIL.—Gilbert Sanders, Esq.; Alphonse Gages, M. R. I. A.; B. B. Stoney, C. E.; Robert S. Reeves, M. A.; John Barker, M. D.; John Good, Esq.; Wm. Frazer, Esq., M. R. I. A.; Joseph O'Kelly, Esq.; C. P. Cotton, C. E.; J. Emerson Reynolds; George Dixon; F. J. Sidney; Rev. H. Lloyd, Provost, T. C. D.; Alex. Carte, M. D., F. L. S.; W. S. Westropp, Esq.; with the Honorary Officers.

HONORARY FELLOWS.

Elected.

1844. 1. Boué, M. Ami, For. Mem., L. G. S., *Paris.*
1865. 2. Burton, Capt. R. F., H. M. Consul, *Santoz.*
1861. 3. Daubrée, M., Membre de l'Institut, 91, *Rue de Gréville, St. Germains, Paris.*
1861. 4. Delesse, M., Ingénieur des Mines, *Paris.*
1865. 5. Des Cloiseaux, M., Prof. of Mineralogy, *Jardin des Plantes, Paris.*
1861. 6. De Serres, M. Marcel, *Montpelier.*
1861. 7. Deville, M. C. Ste Claire, *Paris.*
1861. 8. Deville, M. H. Ste Claire, *Paris.*
1861. 9. De Koninck, M. L., For. Mem., L. G. S., *Liége.*
1861. 10. Geinitz, M. H. B., For. Mem., L. G. S., *Dresden.*
1863. 11. Hunt, Dr. T. Sterry, F. R. S., *Montreal.*
1844. 12. Lyell, Sir Charles, F. R. S., 73, *Harley-street, London, W.*
1861. 13. M'Clintock, Sir Leopold, R. N., 21, *Merrion-square, North.*
1844. 14. Murchison, Sir Roderick I., F. R. S., 16, *Belgrave-square, London, S. W.*
1832. 15. Sedgwick, Rev. A., F. R. S., *Cambridge.*

HONORARY CORRESPONDING FELLOWS.

1859. 1. Gordon, John, C. E., *India.*
1859. 2. Hargrave, Henry J. B., C. E., *India.*
1859. 3. Hime, John, C. E., *Ceylon.*
1858. 4. Kingsmill, Thomas W., *Hong Kong.*
1855. 5. Medlicott, Joseph, *India.*
1854. 6. Oldham, Thomas, F. R. S., *Calcutta.*

FELLOWS WHO HAVE PAID LIFE COMPOSITION.

1853. 1. Allen, Richard Purdy, 10, *Bessboro'-terrace, N. C. Road.*
1861. 2. Armstrong, Andrew, 16, *D'Olier-street.*
1857. 3. Carson, Rev. Joseph, D. D., S. F. T. C. D., *Trinity College.*

Elected.
1857. 4. Dowse, Richard, *Mountjoy-square.*
1861. 5. Fottrell, Edward, 86, *Harcourt-street.*
1862. 6. Frazer, W., M. D., M. R. I. A., 124, *Stephen's-green.*
1857. 7. Greene, John Ball, 6, *Ely-place.*
1857. 8. Haliday, A. H., A. M., F. L. S., M. R. I. A., *Harcourt-street.*
1848. 9. Haughton, Rev. Professor, M. D., F. R. S., 40, *Trinity College.*
1862. 10. Henry, F. H., *Lodge Park, Straffan, Co. Kildare.*
1850. 11. Hone, Nathaniel, M. R. I. A., *St. Doulough's, Co. Dublin*
1861. 12. Hone, Thomas, *Yapton, Monkstown, County Dublin.*
1831. 13. Hutton, Robert, F. G. S., *Putney Park, London.*
1851. 14. Jukes, Joseph Beete, F. R. S., 51, *Stephen's-green.*
1867. 15. Kane, Sir R., 51, *Stephen's-green.*
1834. 16. King, Hon. James, M. R. I. A., *Mitchelstown.*
1866. 17. Lalor, J. J., *Longford-terrace, Monkstown.*
1856. 18. Lentaigne, John, M. D., *Great Denmark-street.*
1848. 19. Luby, Rev. Thomas, D. D., S. F. T. C. D., *Trinity College.*
1851. 20. Malahide, Lord Talbot de, F. R. S., *Malahide Castle, Malahide.*
1867. 21. Malet, Rev. J. A., D. D., S. F. T. C. D., *Trinity College, Dublin.*
1838. 22. Mallet, Robert, C. E., F. R. S., 1, *The Grove, Clapham-road, London.*
1846. 23. Murray, B. B., *County Survey Office, Downshire-road, Newry.*
1859. 24. Ogilby, William, F. G. S., *Liscleen, Dunmanagh, Co. Tyrone.*
1849. 25. Sidney, F. J., LL. D., 19, *Herbert-street.*
1864. 26. Symes, Richard Glascott, 51, *Stephen's-green.*
1851. 27. Whitty, John Irvine, LL. D., 35, *Lower Mount-street.*

FELLOWS WHO HAVE PAID HALF LIFE COMPOSITION.*

1854. 1. Barnes, Edward, *Ballymurtagh, Co. Wicklow.*
1866. 2. Bradley, Samuel, *Little Castle, Castlecomer.*
1832. 3. Bryce, James, LL. D., F. G. S., *High School, Glasgow.*
1862. 4. Carter, T. S., *Watlington Park, Watlington, Oxfordshire.*
1854. 5. Clemes, John, *Luganure Mine, Glendalough, Co. Wicklow.*
1857. 6. Crawford, Robert, C. E., *care of Messrs. Peto and Betts*, 9, *Great George's-street, Westminster, S. W.*
1861. 7. Crosbie, William, *Ardfert Abbey, Ardfert, Tralee.*
1866. 8. Duffin, W. E. L'Estrange, *Maghera Rectory, Co. Down.*
1861. 9. Dunally, Lord, *Kilboy, Nenagh.*
1856. 10. Du Noyer, G. V., M. R. I. A., 51, *Stephen's-green.*
1832. 11. Dunraven, Earl of, F. R. S., *Adare, Co. Limerick.*
1866. 12. Ellis, R. H., *The Hill, Monkstown.*
1836. 13. Enniskillen, Earl of, F. R. S., M. R. I. A., *Florence Court, Enniskillen.*
1844. 14. Esmonde, Sir Thomas, Bart., M. R. I. A., *Johnstown Castle, Wexford.*
1866. 15. Graves, S. R., M. P., *Wavertree, Liverpool.*
1853. 16. Harkness, Professor, F. R. S., *Queen's College, Cork.*
1861. 17. Harte, W., C. E., *Buncrana, Donegal.*
1856. 18. Haughton, Lieut. John, R. A.
1850. 19. Head, Henry, M. D., 7, *Fitzwilliam-square.*
1858. 20. Hill, J., C. E., *Ennis, Co. Clare.*
1862. 21. Hudson, R., F. R. S., F. L. S., *Clapham Common, London.*
1865. 22. Jacob, Arthur, B. A., *Town Hall, Croydon, Surrey.*
1839 23. James, Sir H., Colonel, R.E., F.R.S., *Ordnance Survey Office, Southampton.*

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* EXTRACT FROM BY-LAWS.

"Any person not residing for more than sixty-three days in each year within twenty miles of Dublin, shall be a Fellow for Life, or until he comes to reside within the above distance, on paying to the Treasurers the sum of £5 5*s.*

"Any non-resident Life Fellow who shall reside within twenty miles of Dublin for more than sixty-three days in any one year, shall cease to be a Fellow, unless he shall either pay an additional composition of £5 5*s.*, or shall pay a subscription of 10*s.* 6*d.* for each year in which he shall so reside for more than sixty-three days."

Elected.
1832. 24. Kearney, Thomas, *Pallasgreen, Co. Limerick.*
1857. 25. Keane, Marcus, *Beech Park, Ennis, Co. Clare.*
1835. 26. Kelly, John, 38, *Mountpleasant-square, Rathmines.*
1853. 27. Kinahan, George H., 28, *D'Olier-street.*
1862. 28. Kincaid, Joseph, Jun., C. E., 9, *Spring-gardens, London, S. W.*
1838. 29. Larcom, Major-General Sir Thomas, R. E., LL. D., F. R. S., *Phœnix Park.*
1858. 30. Leech, Lieut.-Colonel, R. E., 3, *St. James's-square, London, S. W.*
1840. 31. Lindsay, Henry L., C. E., *Melbourne, care of J. Bower, Esq., C.E.*, 28, *South Frederick-street.*
1867. 32. Meadows, J. M'Carthy, *Athy.*
1840. 33. Montgomery, James E., M. R. I. A.
1856. 34. Molony, C. P., Capt., 25th Regt., Madras N. I., *per Messrs. Grinlay and Co.*, 3, *Cornhill, London.*
1856. 35. Medlicott, Henry B., F. G. S., *Geological Survey of India, per Smith and Elder, Cornhill, London, E. C.*
1857. 36. M'Ivor, Rev. James, *Rectory, Moyle, Newtownstewart, Co. Tyrone.*
1865. 37. Morton, G. H., 7, *London-road, Liverpool.*
1845. 38. Neville, John, C. E., M. R. I. A., *Dundalk.*
1852. 39. O'Kelly, Joseph, 54, *Stephen's-green.*
1832. 40. Renny, Henry L., R. E., *Canada.*
1865. 41. Scott, J. M., *Bengal Presidency College, Calcutta.*
1854. 42. Smyth, W. W., F. R. S., *Jermyn-street, London.*
1865. 43. Steele, Rev. W., *Portora Royal School, Enniskillen.*
1857. 44. Tait, Alexander, C. E., *Queen's Elms, Belfast.*
1832. 45. Tighe, Right Hon. William, *Woodstock, Innistiogue.*
1866. 46. Townsend, H. W., *Clonakilty.*
1866. 47. Wall, H. P., *Portarlington.*
1864. 48. Waller, G. A., *St. James's-gate.*
1853. 49. Webster, William B., 104, *Grafton-street.*
1861. 50. Whitney, C. J., *Brisbane, Queensland.*
1846. 51. Willson, Walter, 51, *Stephen's-green.*
1854. 52. Wyley, Andrew, 51, *Stephen's-green.*
1857. 53. Wynne, Arthur B., F. G. S., 51, *Stephen's-green.*

ANNUAL FELLOWS.

1861. 1. Andrews, William, *Ashton, Monkstown.*
1831. 2. Apjohn, James, M. D., F. R. S., *South-hill House, Blackrock.*
1867. 3. Baily, W. H., *Stephen's-green.*
1857. 4. Bandon, Earl of, D. C. L., *Castle Bernard, Bandon, Co. Cork.*
1859. 5. Barker, John, M. D., 83, *Waterloo-road.*
1861. 6. Barrington, C. E., *Fassaroe, Bray.*
1862. 7. Barrington, E., *Fassaroe, Bray.*
1862. 8. Barton, H. M., 5, *Foster-place.*
1864. 9. Bateman, C. W., LL. B., *West End, Mallow.*
1859. 10. Battersby, Francis, M. D., 15, *Warrington-place.*
1844. 11. Bective, Earl of, *Headfort, Kells.*
1862. 12. Bennett, E., M. B., 2, *Upper Fitzwilliam-street.*
1857. 13. Bolton, George, Jun., 6, *Ely-place.*
1861. 14. Bolton, H. E., 6, *Ely-place.*
1864. 15. Bradshaw, G. B., 7, *Monkstown-crescent. Co. Dublin.*
1831. 16. Brady, Right Hon. Maziere, 26, *Upper Pembroke-street.*
1861. 17. Brownrigg, W. B., *Brannockstown, Co. Kildare.*
1840. 18. Callwell, Robert, M. R. I. A., 25, *Herbert-place.*
1857. 19. Carte, Alexander, A. M., M. D., F. L. S., *Royal Dublin Society.*
1867. 20. Clarke, G. R., *Belfast.*
1862. 21. Close, Rev. Maxwell, *Newtownpark, Blackrock.*
1858. 22. Cotton, Charles P., C. E., 11, *Lower Pembroke-street.*
1862. 23 Cousins, A. L., C. E., 60, *Harcourt-street.*

Elected.
1834. 24. Croker, Charles P., M. D., 7, *Merrion-square, West.*
1863. 25. Crook, Rev. R., LL. D., 2, *St. John's-road, Sandymount.*
1853. 26. De Vesci, Lord, *Abbeyleix House, Abbeyleix.*
1863. 27. Dixon, G., 32, *Holles-street.*
1849. 28. Downing, Samuel, C. E., LL. D., 6, *Trinity College.*
1852. 29. Doyle, J. B., *Derrymore House, Newry.*
1867. 30. Dunscombe, Clement, *King William's Town, Co. Cork.*
1866. 31. Edgeworth, D. B., C. E., *Kildare street Club.*
1865. 32. Fleming, John M., *Royal Engineers' Department, Royal Barracks.*
1866. 33. Foot, A. W., M. D., *Upper Pembroke-street.*
1867. 34. Forster, R., *University Club.*
1858. 35. Gages, Alphonse, M. R. I. A., 51, *Stephen's-green.*
1864. 36. Gahan, A., C. E., *Omagh.*
1849. 37. Galbraith, Rev. Joseph A., F. T. C. D., *Trinity College.*
1865. 38. Gibson, John, C. E., *Stapleton-place, Dundalk.*
1867. 39. Gore, J. E., 11, *Synge-street.*
1865. 40. Gray, R. A., C. E., 5, *Palmerston Villas, Upper Rathmines.*
1859. 41. Green, Murdock, 52, *Lower Sackville-street.*
1862. 42. Gribbon, C. P., 72, *Stephen's-green.*
1831. 43. Griffith, Sir R., Bart., LL. D., F. G. S., 2, *Fitzwilliam-place.*
1856. 44. Good, John, *City-quay.*
1857. 45. Hampton, Thomas, C. E., 6, *Ely-place.*
1866. 46. Heron, Robert, *Ormond-quay.*
1861. 47. Hudson, A., M. D., *Merrion-square.*
1865. 48. Hutton, T. M., 118, *Summer-hill.*
1852. 49. Jellett, Rev. Professor, F. T. C. D., M. R. I. A., 9, *Trinity College.*
1842. 50. Jennings, F. M., M. R. I. A., F. G. S., *Brown-street, Cork.*
1862. 51. Kinahan, G., J. P., *Roebuck-hill, Dundrum.*
1866. 52. Knapp, W. H., C. E., 6, *Belgrave-square, Monkstown.*
1865. 53. Leech, John, C. E., 6, *Ely-place.*
1831. 54. Lloyd, Rev. Humphrey, D. D., F. R. S., Provost T. C. D., *Provost's House.*
1863. 55. Macalister, A., M. D., 13, *Adelaide-road.*
1855. 56. M'Causland, Dominick, 12, *Fitzgibbon-street.*
1861. 57. M'Comas, A., 23, *Rathmines-road.*
1865. 58. M'Donnell, Alexander, C. E., *St. John's, Inchicore.*
1851. 59. M'Donnell, John, M. D., 4, *Gardiner's-row.*
1837. 60. Mollan, John, M. D., 8, *Fitzwilliam-square.*
1859. 61. Moore, Joseph Scott, J. P., *Hume-street.*
1831. 62. Nicholson, John, M. R. I. A., *Balrath House, Kells.*
1856. 63. O'Brien, Octavius, 23, *Kildare-street.*
1865. 64. Ollis, G., *The Camp, Aldershott.*
1864. 65. Palmer, Sandford, *Roscrea.*
1865. 66. Porte, G., *Beggarsbush-road.*
1857. 67. Porter, William, C. E., *Leinster Club, Clarè-street.*
1865. 68. Radley, John, *Gresham Hotel, Sackville-street.*
1864. 69. Reynolds, Emerson J., *Royal Dublin Society.*
1857. 70. Reeves, R. S., 22, *Upper Mount-street.*
1861. 71. Roberts, W. G., *Nenagh, Co. Tipperary.*
1862. 72. Rowan, D. J., C. E., *Dundalk.*
1864. 73. Russell, H., *Simmon's-court.*
1852. 74. Smith, Robert, M. D., 63, *Eccles-street.*
1852. 75. Sanders, Gilbert, M. R. I. A., *The Hill, Monkstown.*
1854. 76. Scott, Robert H., F.G. S., *Meteorological Office, 2, Parliament-street, London.*
1864. 77. Scovell, F., *Blackrock.*
1866. 78. Stewart, H., M. D., *Lucan.*
1859. 79. Stokes, William, M. D., F. R. S., 5, *Merrion-square, N.*
1861. 80. Stoney, Bindon, C. E., 42, *Wellington-road.*

Elected.

1862. 81. Taylor, Colonel Meadows, M. R. I. A., *Old-court, Harold's-cross.*
1864. 82. Tichborne, C. R. C., *Apothecaries' Hall, Mary-street.*
1862. 83. Trench, W. R., *University Club, Stephen's-green.*
1859. 84. Waldron, L., LL. D., *Ballybrack, Dalkey.*
1863. 85. Westropp, W. H. S., M. R. I. A., 2, *Idrone-terrace, Blackrock.*
1863. 86. Williams, R. P., 38, *Dame-street.*
1851. 87. Wright, Edward, LL. D., M. R. I.. A., *Flora-ville, Donnybrook.*
1864. 88. Wright, Joseph, 39, *Duncan-street, Cork.*

ASSOCIATES FOR THE YEAR.

1. Clibborn, J., 13, *Leeson-park.*
2. Dwyer, F., 45, *Upper Sackville-street.*
3. Edmondson, J. W., *Foxrock.*
4. Greene, J. F., 63, *Lower Gardiner-street.*
5. Grffith, J. P., 2, *Trinity College, Dublin.*
6. Heath, F., *Harold's-cross.*
7. Neville, E. K., 18, *Trinity College, Dublin.*
8. Ryan, J. H., 34, *Leeson-park.*
9. West, C. D., *St. Patrick's Deanery.*

No. II.

LIST OF FELLOWS GAINED AND LOST.

DURIRG THE YEAR ENDING JANUARY 31, 1868.

FELLOWS GAINED.

Life.

1. Kane, Sir Robert, 51, *Stephen's-green.*
2. Malet, Rev. J. A., D. D., *Trinity College, Dublin.*

Half Life.

1. Meadows, J. M'Carthy, *Athy.*

Annual.

1. Clarke, G. R., *Belfast.*
2. Dunscombe, Clement, *Co. Cork.*
3. Forster, R., *University Club.*
4. Gore, John E., 11, *Synge-street.*

FELLOWS LOST.

Life.

1. Brown, Markham, *Westland-row.* Deceased.

Annual.

1. Harold, J., *Ormond-quay.* Resigned.
2. M'Clintock, A.. M. D., *Merrion-square, N.* Do.

State of the Society at the commencement of—

	Year 1867.	Year 1868.
Honorary Fellows,	15	15
Corresponding do.,	6	6
Life do.,	79	80
Annual do.,	85	88
	185	189

No. III.

DONATIONS RECEIVED TO JANUARY 31, 1868.

Amsterdam.—Kon. Akademie van Wettenschapen, Verslagen en Mededeelingen, Second Series, 1866.

——— Jaarboek, 1866.

——— Catalogus Boekeri, Part 2, Vol. I.

Berlin.—Deutsche Geologische Gesellschaft, Zeitschrift, Vol. XVIII., Parts 1, 4.

——— Zeitschrift der Gesellschaft für Allgemeine Erdkunde, Nos. 9 and 10, Vol. II., Part 2.

——— Zwolfter Berichte der oberkeasischen Gesellschaft für Natur- und Heilkunde, February, 1867.

Bologna.—Accademia delle Scienze dell' Istituto, Memorie, Tom IV., Parts 2–4; Tom V., Parts 1, 2.

Boston.—Natural History Society. Proceedings, Vol. XI.; 1.

———Annual Reports, Vol. I., 1866.

Bremen.—Abhandlungen herausgegeben vom Naturwissenschaftlichen Vereine. Vol. I., Part 3.

Brussels.—Academie Royale, Annuaire, 1868.

——— Bulletin, Vols. XXIII., 1867.

Caen—Société Linnéenne de Normandie, Bulletin, Vol. X., Part 1.

Cambridge, U. S. A.—Annual Report of the Trustees of the Museum of Comparative Zoology at Harvard College. 1866.

Dijon.—Memoires de L'Academie Imperiale, Vol. II.

Dresden.—Sitzungsberichte der Naturwissenschaftlichen Gesellschaft, Isis, 1866, Nos. 10, 12; and 1867, Nos. 1-9.

Dublin.—Royal Dublin Society, Journal, No. 36.

Glasgow.—Geological Society, Transactions, Vol. II., Part 3.

———Philosophical Society of, Proceedings, 1866, 7.

Haarlem.—Archives Neerlandaises des Sciences exactes et naturelles, 1867, Vol. II., Parts 3, 4, and 5.

———Naturkundige Verhandelingen van de Hollandsche Maatschappij der Wetensschappen, Vol. XXI., Part 2; XXII., 1, 2; XXIII.

Halle.—Naturwissenschaftliche Verein für Sachsen und Thüringen in Halle. Zeitschrift für die gesammten Naturwissenschaften, Vol. XXVI.

India.—Geological Survey, Memoirs of, Vol. VI.

——— Annual Report, 1866, 7.

——— Catalogue of Organic Remains belonging to the Cephalapoda.

Kilkenny.—Kilkenny and South-East of Ireland Archæological Society, Proceedings and Papers, Vol. V., Nos. 53, 54.

Leipsic.—K. Sächsische Gesellschaft der Wissenschaften, Abhandlungen, Vol. VII., 2–4; Preisgekrönt und herausgegeben von der Fürstlish Tablownowzkischen Gesellschaft, 1867.

——— Berichte über die Verhandlungen, 1866.

Leeds.—The Geological and Natural History Repertory, No. 13.

——— Philosophical and Literary Society, Annual Reports, 1866, 7.

——— Catalogue of Library, 1867.

——— Geological Society, 1866, 7.

Lausanne.—Société Vaudois des Sciences Naturelles, Bulletin, Vol. IX., 57.
London.—Geological Society, Quarterly Journal, Vol. XXIII., Parts 90, 91, 92, 99.
——— Royal Geographical Society, Journal, Vol. XXXV.
————————— Proceedings, Vol. XI., Parts 1, 2, 3, 4, 5.
——— Royal Society, Proceedings, Vol. XV., Nos. 89, 90, 91, 92, 93, 95, 97, 100.
——— British Association Report, 1866.
——— Linnean Society, Journal of Proceedings, Vol. X., Nos. 40, 41, 44.
————— Botany, Vol. IX., Part 39.
————— Zoology, Vol. IX., Part 39.
——— Zoological Society, Proceedings, 1866, Parts 1-3; 1867, Parts 1, 2.
————— Report of Council, 1867.
——— Geologists' Association, Annual Report, 1867.
——— Institution of Civil Engineers, Minutes of Proceedings, Vol. XXVI.
Lyons.—Memoires de l'Academie Imperiale des Sciences Belles Lettres et Arts, Vols. XII.-XV.
——— Annales de la Société d'Agriculture, Vol. XI., 1866.
——— Annales des Sciences Physique de l'Academie Imperiale, Vol. IX., 1865.
Manchester.—Literary and Philosophical Society, Memoirs, 3rd Series; Proceedings Vol. V.
——— Geological Society, Transactions, Vo. VI., Parts 3, 4, 7.
Milan.—Reale Instituto Lombardo de Scienze, Rendiconti, Vol. III., Parts 1-9.
————— Lettere, Vol. II., Parts 8-10; Vol. III., Parts 1-10.
Montreal.—Natural History Society, The Canadian Naturalist and Geologist, Vol. II., Parts 5, 6.
Munich.—K. Baierische Akademie der Wissenchaften, Sitzungs-berichte, 1867, Vol. I., Parts 1, 2, 3.
Neuchatel.—Bulletin de la Société des Sciences Naturelles, Vol VII., Parts 1, 2.
Newhaven.—The American Journal of Science and Art, Nos. 126, 7, 8, 9, 131, 2, 4. From the Editors.
Paris.—Nouvelle Archives du Museum D. Hist. Nat., Tom. I., II., III.
Philadelphia.—American Philosophical Society, Proceedings, Vol. X., Parts 74, 75.
————— Catalogue of Library, Part 2.
————— Transactions, Vol. XIII., Part 2.
Plymouth.—The Institution, Report of the Transactions, 1867, Vol. II., Part 1.
St. Petersburgh.—Kaiserliche Gesellschaft für die Gesammte Mineralogie. Verhandlungen, 1863.
St. Louis.—Academy of Science, Vol. II., No. 2.
Stockholm.—K. Vetenskaps Akadamiens Forhandlingar. Ofversigte, 1863 and 1866.
Toronto.—Canadian Institute. The Canadian Journal of Industry, Science, and Art. No. 65.
Stuttgart.—Verein für Vaterländische Naturkunde. Würtembergische Naturwissenschaftliche, 1866, 1-3.
Vienna.—K. K. Geologische Reichsanstalt, Jahrbuch, Vol. XII., Part 4; XIII., Part 4; XIV., Part 3; XV., Part 4; XVI., Part 1. From the Director, Prof. Haidinger.
——— Zoologisch-Botanische Gesellschaft, Verhandlungen, 1866.
Washington.—Smithsonian Institution, Report, 1864.
Yorkshire.—Geological and Polytechnic Society of the West Riding of, Report, 1864-5.
Zurich.—Vierteljahrsschrift des Naturforsch. Gesellschaft, 1865.

PRESENTED BY THE AUTHORS.

Caspar, Professor.—Ungedrukte, unbeachtete und wenig beachtete Quellen zur Geschishte des Tanfsymbols und der Glanensregel.
Jukes, Professor.—Her Majesty's Geological Survey of the United Kingdom, and its Connexion with the Museum of Irish Industry.
Baily, W. H.—Figures of characteristic British Fossils, with descriptive Remarks, Part I., Plates 1-10, Cambrian and Lower Silurian.
Haast, Julius.—Report on the Head Waters of the River Rakaia.

No. IV.

SOCIETIES AND INSTITUTIONS TO WHICH THE JOURNAL OF THE ROYAL GEOLOGICAL SOCIETY OF IRELAND IS SENT.

ABERDEEN, .	University Library.
ALBANY, . .	State Library, New York.
AMSTERDAM, .	Royal Academy of Sciences.
ANTWERP, .	Société Palæontologique de Belgique.
BELFAST, . .	Queen's College Library.
BERLIN, . .	Royal Academy of Sciences.
	German Geographical Society.
	German Geological Society, per Besser'sche Buchhandlung, *Behren-str.*, 7, *Berlin.*
BOLOGNA, .	Accademia delle Scienzi dell' Istituto.
BORDEAUX, .	Imperial Academy of Sciences.
BOSTON, . .	American Academy.
	Natural History Society.
BRISTOL, . .	Institution for the Advancement of Science, Literature, and the Arts.
BRÜNN, . .	Naturforschende Verein.
BRUSSELS, .	Academy of Sciences.
CAEN, . . .	Société Linnéenne de Normandie.
CALCUTTA, .	Asiatic Society.
	Public Library.
	Geological Survey of India.
CAMBRIDGE, .	Philosophical Society.
	Trinity College Library.
CANTERBURY, NEW ZEALAND,	Geological Survey.
COPENHAGEN,	Royal Society of Science.
CORK, . . .	Queen's College Library.
	Royal Institution.
DIJON, . . .	Academy of Sciences.
DRESDEN, . .	The "Isis" Society.
DUBLIN, . .	Royal College of Surgeons' Library.
	Royal Irish Academy.
	University Library.
	Royal Dublin Society.
	Natural History Society.
	Ordnance Survey Library.
	Professor Sullivan, as Editor of the "Atlantis."
	Geological Survey of Ireland.
	Institution of Civil Engineers.
EDINBURGH, .	Royal Society.
	Wernerian Society.
	Royal Scottish Society of Arts.
	University Library.
	Society of Antiquaries.
	Advocates' Library.
FALMOUTH, .	Royal Cornwall Polytechnic Society.
FLORENCE, .	Society of Physics and Natural History.
GALWAY, . .	Queen's College Library.
GENOA, . .	Society of Physics.
GLASGOW, . .	University.
	Geological Society.
GÖTTINGEN, .	University.

HAARLEM, .	Société Hollandaise des Sciences, per B. Quarritch, 15, *Piccadilly, London*.
HALLE, . .	Naturwissenschaftliche Verein für Sachsen und Thüringen, per Antons Buchhandlung, *Halle*.
HANAU, . .	Oberhessische Gesellschaft der Natur-und Heil-kunde.
HANOVER, .	Royal Library.
KILKENNY, .	Archæological Society.
KÖNIGSBERG,	Königlich Physikalisch-Oekonomische Gesellschaft.
LAUSANNE, .	Société Vaudoise des Sciences Naturelles.
LEEDS, . .	Geological and Polytechnic Society of the West Riding of Yorkshire.
	Philosophical and Literary Society.
LEIPZIC, . .	Royal Society of Sciences (Saxony).
	University.
LIVERPOOL, .	The Literary and Philosophical Society.
	Historic Society of Lancashire and Cheshire.
	Geological Society, The Royal Institution, *Colquitt-street*.
LONDON, . .	Geological Survey, *Jermyn-street*.
	British Museum.
	Society of Arts, *John-street, Adelphi*.
	Royal Institution, *Albemarle-street*.
	Royal Society, *Burlington House*.
	Geological Society, *Somerset House*.
	Linnean Society, *Burlington House*.
	Royal Geographical Society, 15, *Whitehall-place*.
	Civil Engineers, Institution of, 25, *Great George's-street, Westminster*.
	Royal Asiatic Society, 5, *New Burlington-street*.
	Royal College of Surgeons, *Lincoln's Inn*.
	Zoological Society, 11, *Hanover-square*.
	Athenæum, 14, *Wellington-street, Strand, London, W. C.*
	Anthropological Society, 4, *St. Martin's-place, London, W. C.*
LYONS, . .	La Société Impériale d'Agriculture, d'Histoire Naturelle, et des Arts Utiles.
	Société Linnéenne.
	Academie Impériale, per Treuttel & Würtz, 19, *Rue de Lille, Paris*.
MADRID, . .	Academia de Ciencias.
MANCHESTER,	Literary and Philosophical Society of. [Sec., R. C. Christie.]
	Geological Society.
MELBOURNE, .	Philosophical Institute of Victoria.
	The Public Library, per Bain and Co., 1, *Haymarket, London*.
	The Royal Society.
MILAN, . .	Reale Istituto Lombardo di Scienzi.
MISSOURI, . .	State Survey and University, *Geological Rooms, Columbia, U. S. A.*
MODENA, . .	Institute of Science.
MONTREAL, .	Natural History Society.
MUNICH, . .	Royal Academy of Science (2 copies).
NEUCHATEL, .	Société des Sciences Naturelles.
NEWHAVEN, U. S. A.,	The Editors of Silliman's Journal of Science and Art.
NEW YORK, .	Lyceum of Natural History.
OXFORD, . .	Bodleian Library.
	Ashmolean Society.
PALERMO, .	Accademia di Scienzi e Lettere.
PARIS, . .	Ecole Polytechnique.
	Geological Society.
	L'Ecole Impériale des Mines.
	Institute of France.
	Bibliothéque Impériale.
	Jardin des Plantes, Bibliothéque.

PHILADELPHIA, American Philosophical Society.
Academy of Natural Sciences, per Trübner and Co.
PLYMOUTH, . Plymouth Institution and Devon and Cornwall Natural History Society.
PRESBURG, . Verein für Naturkunde.
QUEBEC, . . Literary and Historical Society.
ROME, . . . The Vatican Library.
ROUEN, . . Academy of Sciences.
ST. ANDREWS, University Library.
ST. LOUIS, . . Academy of Sciences.
ST. PETERSBURG, Imperial Academy.
Central Physical Observatory of Russia.
Russisch-Kaiserliche Mineralogische Gesellschaft.
STOCKHOLM, . Royal Academy of Science, per Longman and Co., *Paternoster-row, London;* and Sampson and Wallis, *Stockholm.*
Geological Survey of Sweden.
STRASBOURG, Société des Sciences Naturelles.
STUTTGART, . Verein für vaterländische Naturkunde.
TORONTO, C.W., Canadian Institute, per Thomas Henning, Esq.
TOULOUSE, . Academy of Sciences.
TRURO, . . RoyalInstitute of Cornwall.
TURIN, . . Royal Academy.
UPSALA, . . Royal Society of Sciences.
VIENNA, . . Imperial Academy of Sciences.
Prof. W. Haidinger, of Vienna, as Editor of the "Jahrbuch der K. K. Geologischen Reichs-anstalt."
K. K. Zoologisch-botanische Gesellschaft, per Braumüller and Co., *Vienna.*
WASHINGTON, Smithsonian Institute Library, per W. Wesley, Esq., 2, *Queen's Head Passage, Paternoster-row, London, E. C.*
WINDSOR, . The Royal Library.
ZURICH, . . Naturforschende Gesellschaft.

No. V.

ABSTRACT OF TREASURER'S ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1867.

Dr.		£ s. d.	£ s. d.
To 1. Balance in Bank, December 31, 1866,			3 14 4
— 2. Balance in Assistant Secretary's hands (same date),			2 8 3
— 3. Subscriptions for 1867:—			
	a. Life,	£24 0 0	
	b. Annual,	86 2 0	
	c. Entrance Fees,	3 3 0	
			115 5 0
— 4. Dividend on Stock for half-year ended April 5, 1867, on £183 13*s.* 3*d.*,			2 14 2
— 5. Ditto for half-year ended October 5, 1867, on £206 18*s.* 1*d.*,			3 1 0
			£127 2 9

Cr.		£ s. d.	£ s. d.
By 1. Petty Cash Book (audited), viz.—			35 12 2
	Porter's Wages,	£12 0 0	
	Tea Fund,	5 10 0	
	Sundries,	18 2 2	
— 2. Salary of Assistant Secretary,			20 0 0
— 3. Cheque Book (Royal Bank),			0 2 1
— 4. Paid for Bookcase,			1 10 0
— 5. Woodcuts,			8 4 0
— 6. Mr. Gill (Printing),			25 0 0
— 7. Woodcut (per ditto),			1 1 0
— 8. Williams and Norgate (Books),			2 18 0
— 9. Invested in Government Stock (Life Compositions),			27 12 0
			£116 19 3
— Balance in Royal Bank, December 31, 1867,		£8 7 5	
— Ditto in Assistant Secretary's hands,		1 16 1	
			10 8 6
			£127 2 9

Audited, and found correct,

February 19, 1868. (Signed) SAMUEL HAUGHTON.
JOHN GOOD.

MINUTES OF PROCEEDINGS FOR THE YEAR 1867-68.

GENERAL MEETING, MARCH 13, 1867.

R. CALLWELL, ESQ., in the Chair.

The minutes of the last meeting were read, compared, and signed; donations announced, and thanks voted.

Mr. Good read a paper "On the finding of a Red Granite Boulder in the Bottom of the Irish Sea," on the slope of a deep submarine ravine, called the Frough, situated about ten miles from Lambay Island.

Professor Jukes made some remarks, and expressed a hope that accurate measurements and details of the nature of the boulder would be obtained by Mr. Good before the publication of his paper.

The Rev. Professor Haughton remarked that he had examined the specimen, and believed it to be similar to the granite of the Mourne Mountains, county of Down, but from what locality it was impossible to determine. It was similar in mineralogical character to several detached masses found on the slopes of these mountains.

Mr. Westropp remarked that he had found masses of Red Granite *in situ* near Newry.

Dr. Barker referred to the description of the deep sea mud given by Mr. Good, and observed that the fetid odour was probably due to the decomposing sarcode masses of foraminiferous organisms.

Mr. Jukes read his paper "On the Subdivision of the Carboniferous Limestones of the Centre of Ireland."

A discussion ensued, in which Dr. Haughton and others joined.

The meeting then adjourned.

GENERAL MEETING, APRIL 12, 1867.

R. CALLWELL, ESQ., in the Chair.

The minutes of the last meeting were read, compared, and signed; donations announced, and thanks voted.

Mr. Andrews read a paper, "On Oyster Deposits, Recent and Fossil," with special reference to some observations upon Oyster Beds in the neighbourhood of Kenmare.

Mr. Good remarked that the Arklow oyster beds are placed upon a bottom of coarse quartz gravel, freed by the strong current from mud and sand, which otherwise would choke the oysters. The Rock-a-bill oysters, on the other hand, are based upon a finer bottom, and become flatter and much larger; this condition is also associated with the absence of a current.

Professor Haughton noticed that, during the excavations made for the purpose of laying the foundation of the New Museum Building, Trinity College, no trace of the existence of an ancient sea beach beneath this locality could be detected.

The Secretary read Mr. Gahan's letter upon "The Finding of a Columnar Structure in Mortar."

Professor Haughton moved, and Mr. Williams seconded, that Mr. Gahan's paper should be referred to the Council for publication, and should be properly illustrated.

The account of a Meteor in South Australia, communicated by Edward Bagot, Esq. was read by the Secretary.

The meeting then adjourned.

GENERAL MEETING, MAY 8, 1867.

W. STOKES, M. D., F. R. S., in the Chair.

The minutes of the last meeting were read, compared, and signed; donations announced, and thanks voted.

Mr. W. Acheson Traill, proposed by Professor Haughton, and seconded by Mr. Callwell, was elected as an Associate Fellow.

The Secretary read the Address presented by the Council to the Provost of Trinity College, upon the occasion of his recent elevation, and the Reply of the Provost. The proceeding of the Council in forwarding the Address was unanimously sanctioned by the meeting; and the Secretary was directed to insert the Address and Reply in the minutes of the meeting.

ADDRESS TO THE PROVOST OF TRINITY COLLEGE.

"TRINITY COLLEGE, *April* 24, 1867.

"REVEREND SIR,—The Royal Geological Society of Ireland beg leave to convey to you, as one of their oldest Members, one of their first Secretaries, and former President, their hearty congratulations on the occasion of your elevation to the Provostship of Trinity College, Dublin.

"In doing so the Fellows cannot but recall the fact, that their first President was your venerated Father, at the time he also held the distinguished post that you now occupy.

"The Fellows take this opportunity of returning you their sincere thanks for having during so many years allowed them the use of one of your chambers in the College as their Council Room and Library, and for the many benefits which they have from time to time received from you.

"They hope that you may long continue to hold the distinguished position which you now occupy.

"Signed on behalf of this Society,

"ENNISKILLEN, *President.*

"SAMUEL HAUGHTON, } *Hon. Secretaries.*
"ALEX. MACALISTER, }

"*To the* Rev. HUMPHREY LLOYD, D. D.,
"*Provost of Trinity College, Dublin.*"

REPLY OF THE PROVOST.

"PROVOST'S HOUSE, TRINITY COLLEGE,
"*April* 25, 1867.

"MY LORD AND GENTLEMEN,—I beg to thank you most sincerely for your kind letter of congratulation on the occasion of my appointment to the Provostship of Trinity College.

"It is quite true that I took some part in the first establishment of the Geological Society of Dublin, and that I have always felt a warm interest in its welfare. Closely connected as it was from the first with Trinity College, the formation of the Society promised to give an impulse to the study of the Natural Sciences in the University; while, on the other hand, there was reason to hope that the mode of studying the science of Geology itself might derive benefit from the connexion, and from the severe habits of reasoning of those who had been trained in the study of the abstract sciences.

"The annals of the Society prove that these hopes have been in great measure realized; that the future of the Society will not be behind the past may be confidently

expected, when it is remembered that it is now under the guidance of one who has himself done so much to illustrate one of the most interesting periods of the past history of our planet. I have the honour to be,

"My Lord and Gentlemen,

"Your most obedient Servant,

"H. Lloyd.

"*To the President and Fellows of the Royal Geological Society of Ireland.*"

Mr. J. Scott Moore read a paper on "The Antiquity of Man," in which he maintained the theory of separate originals for the different races of mankind.

A discussion ensued, in which Professor Haughton, Mr. M'Causland, and others took part.

The meeting then adjourned.

General Meeting, June 12, 1867.

J. Scott Moore, J. P., D. L., in the Chair.

The minutes of the last meeting were read, compared, and signed; donations announced, and thanks voted

The Ballot was declared open; Mr. Good and Dr. Battersby were appointed scrutineers.

Mr. Harte read his paper "On the Post-Tertiary Geology of the County of Donegal, and Part of the County of Londonderry, especially in Comparison with the corresponding Deposits in Scotland."

Mr. Close stated that he differed from the author of the paper in several respects, especially as regarded the ice agencies referred to by Mr. Harte.

Mr. Lalor brought forward some specimens of dendritic markings, and a specimen supposed to be the vertebra of a fish.

Dr. Reynolds made some remarks on the nature of Dendrites.

The Scrutineers reported that Dr. J. A. Malet, S. F. T. C. D., was unanimously elected a Fellow of the Society.

The meeting then adjourned.

EXPLANATION OF PLATE I.

Vide Vol. I., page 284, for the Letter of Mr. G. F. MOORE, illustrated by this Plate.

Fig. 1.	*Gidji Boryl*,	War Spear.
Fig. 2.	*Dappa*,	Knife.
Fig. 3.	*Boomerang*.	
Fig. 4.		Handle for throwing the Spear.
Fig. 5.	*Kadjo*,	Hatchet.
Fig. 6.	*Gidji Garbel*,	Hunting Spear.
Fig. 7.		Crowbar.

XII.—On a New Echinoderm (Spatangoid), supposed to be from the Yellow Sandstone of Scotland. By William Harte, C. E., Co. Surveyor of Donegal.

[Read March 11, 1868.]

I have frequently noticed in the yellow sandstone of Donegal, cavities, the forms of which closely resembled the shape of the Echinidæ, but, with one exception (that of the Archeocidaris-like fossil in your museum, and described by me in the 1st vol. "Journal Royal Geological Society of Ireland") I never could make out any definite markings upon them. The sandstone where this occurs (chiefly at Lough Eske) is often coarse-grained, which may partly be the cause of the absence of finer markings, but there is probably another reason. The Cidarites have very strong shells, and the markings might be more easily preserved; while in the Spatangaceæ (of which the subject of this paper, as I believe, is one) the shell is very thin, and would not alone yield to the least pressure, but the lime would be often almost at once decomposed and absorbed. I found once the interior core of one of these cavities, and which was in shape exactly like Ananchytes, but free from all surface markings whatever. Its condition was exactly like the fossil before you, but there being no evidence beyond its shape as to its being organic, it was not noticed. Now, since I have got this new fossil, I have no doubt but it was a fossil Echinoderm, and a sharp look out ought to be kept to those sandstone cavities in future. Sand, in which they burrow, recollect, is the natural habitat of the Spatangaceæ, and the shells are so fragile that we need scarcely expect to find them fossil in ordinary limestone, but only in sandstone, for sandstone is formed much more rapidly than limestone.

The fossil before you reached me in this way: My friend Captain Skipton, governor of the Derry gaol, knowing my tastes, preserved it for me, and most kindly presented me with it. It fell out of a boulder which was being broken by a prisoner in the gaol of Derry for road-metal. I went to examine the stone and found that it was part of a heap of ballast said to have come from Scotland. The group of stones composing the ballast were decidedly Scotch-looking, viz.—Arenaceous limestone, sandstones, and granites (red and white). The sandstone, as you will see, is exactly in texture and appearance the same as the Lough Eske sandstone, in which my Archeocidaris occurs, and the limestone associated with it, but unfortunately no other fossils could be detected in it. Of course it is hard to say whence it came, but I have no doubt it is from the sandstone of the coal-measures. And I may remark that the bed of sandstone in which I found the other Echinoderm at Lough Eske is also almost destitute of other fossils.

Now, as to this fossil which I have the pleasure of presenting to your museum, as also portion (all I could get) of the matrix, it is

evidently spatangoid in shape, and approaches in that respect nearer to our *Spatangus purpureus*, perhaps, than any other, but it is somewhat more uniform. No plate markings are visible, but we have portions presenting close resemblance to important parts of the Spatangaceæ and in their relative natural positions, such as the oral aperture, and we clearly have the anal opening at the base, where (as in other fossils, often of Echini) it alone adhered to the matrix. What I take to be the dorsal depression is terminal, and there alone may the trace (if any) of ambulacral grooves be detected. That the organic nature of the specimen will be denied I have no doubt, but to one accustomed to notice the conditions in which animal fossils (even of bivalves having thick shells) are found in the pure yellow sandstone, the appearance of this fossil is perfectly natural. The yellow sandstones of Mount Charles in your museum, while they preserve the first surface markings of Lepidodendrons, &c., fail to do so in the case of the bivalves, which can only be identified often by their shape. And when we look at the symmetrical and bilateral arrangement of this fossil, I feel convinced that it is an Echinoderm, and that we will be yet able to fully confirm it before long by perhaps better specimens heretofore overlooked.

I have gone to Scotland to examine its geology sometimes, but it is a novelty, excepting for glacial theories, to find Scotch geology coming to Ireland to be described.

If the stone was found under other circumstances in Donegal or Derry, there could not be the slightest doubt about referring it to the coal-measures, and I have no hesitation in doing so to the same Scotch beds.

Allow me to bespeak for this (at least when we do get the confirmatory evidence I hope for), the generic name of "Paleo-spatangus," and add the specific one of "Skiptonii," after the gentleman whose quick eye secured so interesting a fossil.

XIII.—Note on the Formation of Dendrites. By J. Emerson Reynolds, L. R. C. P., Edin.

[Read April 8, 1868.]

The dendritic forms in which many mineral substances occur have long been familiar to mineralogists and geologists; but notwithstanding the comparatively frequent occurrence of these singular arborescent markings, but little attention seems to have been devoted to their investigation. No doubt dendrites are looked upon by many as the results of curious freaks in the distribution of metals or metallic oxides through rock masses, and their occurrence as being explained on the hypothesis of injection of a liquid or paste; as the results of capillary action; or, when occurring on exposed surfaces, as the products of simple evaporation.

While not wishing to claim for these peculiar markings an importance which they do not really possess in all probability, I still hope that the new facts which I have to bring forward may not only throw light upon the formation of a large class of dendrites, but also lead to increased appreciation of the part which electricity has probably played in the production of certain geological phenomena. This must be my apology for bringing so trivial a matter before the Society.

When staying in Edinburgh, in 1865, Dr. Strethill Wright of that city showed me some very curious figures which he had succeeded in producing with the aid of the secondary current of the induction coil. They were obtained by placing a drop of a saline solution on a plate of glass, and allowing either pole of the coil to dip into the liquid; the drop immediately seemed endowed with vitality, and from its circumference proceeded lines of liquid, which in turn divided and subdivided until the original drop was completely surrounded with a beautiful arborescent pattern. The figures produced depend not only on the density, but on the chemical constitution of the liquid experimented with. The forms obtained in this way by Dr. Wright so closely resembled the limestone dendrites with which we are familiar, that I have since made a number of experiments in order to determine how far electricity may have been instrumental in producing the natural figures. The proof which I have obtained, though, of course, indirect, seems to me to be very strong in favour of the electrical origin of a large number of dendrites.

We are all acquainted with the fact that minerals, when cleaved parallel to their planes of cleavage, give in each case two new surfaces which are in opposite electrical states immediately after separation; this is easily observed in mica, heavy spar, felspar, or talc. Gavarret* states, that when melted sulphur is poured on a glass plate, and allowed to solidify there, on the subsequent separation of the two surfaces they are both found to be in opposite conditions of electrical excitement. The same holds good in the case of cleavable rocks. It is, therefore, proved that on the separation of any two surfaces of chemically and physically like or unlike substances electricity is developed. If we take a plate of mica just removed from the crystal, and place on the centre of the new surface—which is in a state of electrical excitement—a drop of any solution of a metallic salt, lines of liquid at once shoot out from the circumference of the drop, and a true dendritic form is quickly produced. If we draw a line on the excited mica plate, with a feather dipped in a saline solution, the arborescent pattern is developed on either side of the line. In order to succeed in producing these figures, it is necessary to place over or under the plate carrying the drop or line of liqnid the second excited surface of mica.

* "Traité d'Eléctricité," tom. i., p. 392.

Now, in applying the information gained by these simple experiments to the explanation of the mode of formation of dendrites, there can be no difficulty whatever. Almost all the arborescent figures which we meet with in limestone consist essentially of manganese in the state of black oxide, the latter most probably resulting from the decomposition of a proto-salt of manganese; since we know that when a drop of a solution of sulphate or chloride of manganese is allowed to fall on a piece of limestone, the latter quickly takes away the acid from the manganous salt, and in the presence of atmospheric air the manganese is converted into either the brown or black oxide. As it is, therefore, very easy to understand how the black oxide could be formed in this way by the decomposition of a soluble salt of manganese, we may fairly assume that such a decomposition occurs subsequent to the formation of the dendrite. This preliminary is essential to the comprehension of the actual process.

In order to explain the formation of the dendrite, we will now suppose a slight crack to have occurred, the direction of which is inclined to the cleavage plane of a mass of limestone. The crack becomes then filled by capillary attraction, with a solution containing a salt of manganese. Subsequently, owing to unequal contraction or some similar cause, the rock splits along its plane of cleavage, the two new surfaces so produced are now in opposite electrical conditions, and each has a line of liquid slowly oozing out through the crack. The conditions under which an electrical figure is developed are now fully realized. The line of metallic solution representing the position of the crack sends out shoots, which go on repeatedly bifurcating until a very beautiful arborescent pattern is produced. As the two surfaces of rock lose their respective charges of electricity, the formation of the figure is first partially, and then completely checked. The next stage is that of drying of the solution and the subsequent oxidation of the residue already referred to.

It is obvious, that a minute tube filled with liquid would act in the same way as the line of solution above mentioned. If the rock be cleaved so that the plane of separation makes an angle with the axis of the fine tube, the aperture of the latter on the new surface would be more or less circular. The lines of liquid radiate from this as centre, and the form of the resulting dendrite is therefore circular. We thus have two kinds of figures accounted for—those developed on each side of a line, and those apparently radiating from a point.

There can be little doubt that both forms of dendrites are really much more common than has hitherto been supposed; but, owing to the absence of salts of the heavy metals from the solutions producing them, the saline residue is indistinguishable in point of colour from the rock surface upon which it lies, and therefore escapes observation. In conclusion, I may mention that the theory of dendritic growths which I have proposed is beautifully illustrated by some specimens amongst the mineral collections of the Royal Dublin Society, but more especially by a fine limestone dendrite from Pappenheim, in Swabia.

XIV.—On some Points in the Classification of the Silicates. By J. Emerson Reynolds, L. R. C. P., Edin., Keeper of the Minerals, and Analyst of the Royal Dublin Society.

[Read May 13th, 1868.]

The views of the mineral chemists, relative to the constitution of the various natural silicates, have undergone considerable change within the last few years. The general adoption of the new equivalent 28 for silicon, and the consequent formula SiO_2 (where $O=16$) for silica, has materially operated in bringing about a more just conception of the silicates, as a whole, than was possible when the old notation was used.

Notwithstanding the advantages gained by the use of the new formula in the study of siliceous minerals, the complexity of the molecules of many of the silicates is so great as to render ordinary views, as to their structure, unsatisfactory in many respects. No doubt this cause has materially operated against the universal acceptance of the altered formula. But where inorganic chemistry has failed, the organic department of the science steps in to our aid, and enables us to apply to the elucidation of the silicates the well known theory of condensed organic acids and hydrates. This has been done to a limited extent by Professor Frankland, M. Wurtz, Dr. Odling, and M. Naquet; but these distinguished chemists have each considered the silicates as forming part of a general chemical system, and have not dealt with the question in its essential bearing upon practical mineralogy.

My object in the present paper is to give a general outline of the views which I hold relative to the mode of carrying out a practical classification of silicates on the principles of condensation and successive hydration of the typical acid. Previous to doing so, I may give the following table of some of the chief chemical elements, arranged according to their degrees of atomicity. This is done less for the purpose of reference than for that of defining the chemical ground on which the subsequent statements rest.

Table I.

Monatomic.	Diatomic.	Triatomic.	Tetratomic.	Pentatomic.
H = 1	O = 16		Si = 28	As = 75
K = 39	Ba = 137	Bo = 11	C = 12	Sb = 122
Na = 23	Ca = 40		Sn = 118	Bi = 210
Li = 7	Mg = 24		Pb = 207	
	Fe = 56		Al = 27·5	

On this plan it will be observed that the formula of water is H_2O, and of silica, SiO_2.

As a starting point, we may take the hypothesis now admitted by most chemists to be true—viz., that silicic anhydride SiO_2 is capable of almost indefinite polymeric modification;* that is to say, we may have SiO_2, Si_2O_4, Si_3O_6, Si_4O_8, &c., all being, obviously, multiples of SiO_2 by 2, 3, 4, &c. Now these anhydridæ—if I may use the expression—are well known to be capable of combining with different proportions of water, so as to form typical hydrates or acids, which can be easily shown to have their representatives in the mineral kingdom. Thus, a hydrate of SiO_2 has been obtained by Doveri, having for its formula SiO_2, H_2O, this hydrate is exactly represented by the mineral Wollastonite, SiO_2 $Ca''O$, in which the diatomic element Ca'' represents the two atoms of monatomic H in the acid.

I may now refer to the symbolic representation of the silicic acids and their salts which I adopt.

We may take the case of the silicate just referred to. Professor Dana† has written the formula of this mineral—employing the new notation—as follows:—

$$SiO \mid O_2 \mid Ca.$$

This obviously involves the necessity for supposing that one atom of the three of oxygen is more closely united with the silicon than either of the other two—a view not borne out by the known decompositions of silicates, and therefore not likely to gain acceptance, notwithstanding the weight which must be attached to any proposal emanating from so distinguished an observer as Professor Dana. Again, M. Wurtz would write Wollastonite $\left.\begin{matrix} Si \\ Ca'' \end{matrix}\right\} O_3$, on the well-known water type. Now I contend that in writing formulæ in either of the above ways, the ratio between the oxygen of the base and that of the anhydride is completely hidden; and since we are not yet in a position to do without some aid of this kind in practice, I propose the use of the following construction, which in the case of Wollastonite becomes $\begin{array}{ccc} & Si & \\ Ca'' & \times & O \\ & O_2 & \end{array}$; those bodies placed vertically or horizontally opposite to each other, are regarded as being most closely united. This seems to me to

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* The recent discovery by M. Debray of the remarkable compounds, which he represents by the formula—

$$1.\ PO_5,\ 20MoO_3$$
$$2.\ PO_5,\ 5MoO_3,$$

leaves no doubt as to the great tendency of molybdic anhydride to multiply itself in combination, and in these states of condensation to yield different hydrates of unmistakeable individuality as to crystalline form, &c. M. Marignac has given similar proof of the existence of this tendency in tungstic anhydride, and has succeeded in producing a series of silico-tungstic acids. These facts obviously have an important bearing on the question of condensation referred to in the text.

† "Silliman's Journal," vol. xliv., p. 257.

be the construction most in accordance with facts, and appears, moreover, to best represent the symmetrical structure of the molecule of a silicate; the oxygen ratio of a compound; and, as I shall now endeavour to show, the mutual relations of great families of minerals.

In adopting this plan in the cases of the silicates, the formulæ of which are given below, I seek to show much more than the mere composition of some of the minerals belonging to the several groups. If we disregard the minor subdivisions, it is shown that all the anhydrous mineral silicates may be divided into two great classes—(1) the silicates which contain in each molecule the elements of SiO^2 only, and (2) those which contain but $3(SiO^2) = Si^3$* O^6, or a multiple of this quantity. My chief object is, therefore, to endeavour to establish *a definite rate of condensation for the acid radicle of silicates;* and in seeking to develope this view my formulæ for siliceous minerals necessarily differ wholly from those employed by other mineralogists.

When the force of the division above alluded to is realized, I believe that much of the difficulty at present attending the study of the mineral silicates will be found to have disappeared; moreover, the relations of groups of minerals become quickly evident when their formulæ are constructed in accordance with the principles above stated.

Silicic Hydrates.

1. *Hydrates of* SiO^2.—Frankland† states that the normal hydrate (1) is the body separated from a soluble silicate by treatment with a stronger acid. Professor Graham's compound (2) corresponds well to the formula of the dibasic acid.‡

$$(1)\quad \begin{array}{ccc} & Si & \\ H^4 & \times & O^2 \\ & O^2 & \end{array} \quad \text{and (2)} \quad \begin{array}{ccc} & Si & \\ H^2 & \times & O. \\ & O^2 & \end{array}$$

In the absence of distinct evidence to the contrary, we may regard the above as silicic hydrates uncondensed. All the salts of the uncondensed SiO^2 are formed on one or the other of the above types.

We have now the second great division of the silicic hydrates and metallic salts, i. e. that comprising the hydrates of $\mathbf{Si}O^6 = 3(SiO^2)$, or a simple multiple of this.

2. *Hydrates of* $\mathbf{Si}O^6$.—(*a*) First amongst these hydrates may be placed that prepared and analyzed by Doveri,§ and which may be well re-

* Hereafter in the text Si (= 28) is used to represent the silicon as it occurs in SiO^2, and ($\mathbf{Si}$ = 84), as in $\mathbf{Si}O^6$, the condensed anhydride. The convenience of this distinction is very considerable.

† "Lecture Notes," p. 101.

‡ "Philosophical Transactions," 1861, p. 204.

§ "Ann. de Chim. et de Phys." (3,) vol. xvi., p. 129.

presented by the formula $H^2 \overset{Si}{\underset{O^6}{\times}} O$. This corresponds precisely to Graham's uncondensed acid.

(*b*) The next hydrates are those of $2 SiO^6$; and Salvetat's mineral, Randanite,* $H^2 \overset{Si^2}{\underset{O^{12}}{\times}} O$, exactly corresponds to one hydrate of this body. Fuchs's compound† is probably another hydrate of the same acid, viz. $H^6 \overset{Si^2}{\underset{O^{12}}{\times}} O^3$; and we may have Ebelmen's compound‡ as a third of the series, $H^{18} \overset{Si^2}{\underset{O^{12}}{\times}} O^9$.

(*c*) In this subdivision we have the hydrates of $3SiO^6$, which are few in number. Some varieties of semiopal appear to consist of the first hydrate, $H^2 \overset{Si^3}{\underset{O^{18}}{\times}} O$. It will be seen further on that orthoclase can be best represented as constructed on the type of the hydrate $H^{12} \overset{Si^3}{\underset{O^{18}}{\times}} O^6$.

It is a singular fact, and one well worthy of remark in this connexion, that the proportion of water found in all the native hydrates of silica hitherto analyzed is such that the specimens containing most water would be best represented by the formula $H^2 \overset{Si}{\underset{O^6}{\times}} O$, and those containing least water fall into the *c* series above, as $H^2 \overset{Si^3}{\underset{O^{18}}{\times}} O$, while Randanite, $H^2 \overset{Si^2}{\underset{O^{12}}{\times}} O$, is the intermediate term required. It is quite true that we know little of the function of the water in these compounds; but the above proportion would appear to be the result of more than mere accident, especially when viewed in connexion with

* Quoted in Dana's "Descriptive Mineralogy," new edition, 1868, p. 200. The above is the formula of the mineral dried at 100° C.

† "Ann. der Chem. und Pharm." vol. xxxii., p. 119.

‡ "Ann. de Chim. et de Phys." (3), vol. xvi., p. 129.

the relations exhibited below between some of the silicic acids and their corresponding metallic salts.

General Classification of the Anhydrous Silicates.

*Acid or Bisilicates.**

		New atomic weights.		Old atomic weights.†	Oxygen ratio.
Class 1.	Type of class .	$\underset{O^2}{\overset{Si}{H^2 \times O}}$	=	$\underset{O^2}{\overset{Si}{H \times O}}$	1 : 2.
Class 2.	,,	$\underset{O^6}{\overset{Si}{H^6 \times O^3}}$	=	$\underset{O^6}{\overset{Si}{H^3 \times O^3}}$	1 : 2.
Class 3.	,,	$\underset{O^{12}}{\overset{Si^2}{H^6 \times O^3}}$	=	$\underset{O^{12}}{\overset{Si^2}{H^3 \times O^3}}$	1 : 4.

All the acid silicates can be well represented on either of the above three types.

Normal or Unisilicates.

Class 1.	Type	$\underset{O^2}{\overset{Si}{H^4 \times O^2}}$	=	$\underset{O^2}{\overset{Si}{H^2 \times O^2}}$	1 : 1.
Class 2.	,, ...	$\underset{O^6}{\overset{Si}{H^{12} \times O^6}}$	=	$\underset{O^6}{\overset{Si}{H^6 \times O^6}}$	1 : 1.
Class 3.	,, ...	$\underset{O^{12}}{\overset{Si^2}{H^{12} \times O^6}}$	=	$\underset{O^{12}}{\overset{Si^2}{H^6 \times O^6}}$	1 : 2.
Class 4.	,, ...	$\underset{O^{18}}{\overset{Si^3}{H^{12} \times O^6}}$	=	$\underset{O^{18}}{\overset{Si^3}{H^6 \times O^6}}$	1 : 3.

* Since this paper was written the new edition of Dana's "Descriptive Mineralogy" has been issued from the press. The nomenclature and order of reference to the silicates originally adopted in this paper have accordingly been altered so as to harmonize with the arrangement employed in Dana's work.

† By contrasting the old and new type-formulæ, when constructed on the plan proposed in this paper, it will be seen how very easy the transition from the equivalent to the atomic notation really is.

Basic Silicates.

	New atomic weights.		Old atomic weights.	Oxygen ratio.
Class 1. Type	$\begin{array}{ccc} & Si & \\ H^{16} & \times & O^{8} \\ & O^{6} & \end{array}$	=	$\begin{array}{ccc} & Si & \\ H^{8} & \times & O^{8} \\ & O^{6} & \end{array}$	4 : 3.
Class 2. ,, ...	$\begin{array}{ccc} & Si & \\ H^{18} & \times & O^{9} \\ & O^{6} & \end{array}$	=	$\begin{array}{ccc} & Si & \\ H^{9} & \times & O^{9} \\ & O^{6} & \end{array}$	3 : 2.
Class 3. ,, ...	$\begin{array}{ccc} & Si & \\ H^{24} & \times & O^{12} \\ & O^{6} & \end{array}$	=	$\begin{array}{ccc} & Si & \\ H^{12} & \times & O^{12} \\ & O^{6} & \end{array}$	2 : 1.

Bisilicates.

Class 1.

Enstatite . . . . . $\begin{array}{ccc} & Si & \\ Mg'' & \times & O \\ & O^{2} & \end{array}$

$= SiO \,\|\, O^{2} \,\|\, Mg''$ (Dana*).

Hyperstthene $\begin{array}{ccc} & Si & \\ (Mg, Fe)'' & \times & O \\ & O^{2} & \end{array}$

Wollastonite . . . $\begin{array}{ccc} & Si & \\ Ca'' & \times & O \\ & O^{2} & \end{array}$

Pyroxene . . . . $\begin{array}{ccc} & Si & \\ R^{2} & \times & O \\ & O^{2} & \end{array}$

Rhodonite . . . . . $\begin{array}{ccc} & Si & \\ Mn'' & \times & O \\ & O^{2} & \end{array}$

Amphibole . . . . . $\begin{array}{ccc} & Si & \\ R^{2} & \times & O \\ & O^{2} & \end{array}$

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* With each class I give Dana's new formula for the first member of the group.

Anthophyllite $$\begin{array}{ccc} & Si & \\ (\tfrac{3}{4}Mg+\tfrac{1}{4}Fe)'' & \times & O \\ & O^2 & \end{array}$$

Class 2.

Ægirite . . $$\begin{array}{ccc} & Si & \\ (\tfrac{1}{2}R^6+\tfrac{1}{2}Fe) & \times & O^3 \\ & O^6 & \end{array}$$

$$= SiO \,\|\, O^2 \,\|\, (\tfrac{1}{2}(Na^2, R) + \tfrac{1}{2}\beta Fe) \text{ (Dana).}$$

Acmite . . $$\begin{array}{ccc} & Si & \\ (\tfrac{1}{3}R^6+\tfrac{2}{3}Fe) & \times & O^3 \\ & O^6 & \end{array}$$

Babingtonite . $$\begin{array}{ccc} & Si & \\ (\tfrac{3}{4}R^6+\tfrac{1}{4}Fe) & \times & O^3 \\ & O^6 & \end{array}$$

Beryl . . . $$\begin{array}{ccc} & Si & \\ (\tfrac{1}{2}Be''^3+\tfrac{1}{2}Al) & \times & O^3 \\ & O^6 & \end{array}$$

Pollucite . . $$\begin{array}{ccc} & Si & \\ (Cs^6+Al) & \times & O^3 \\ & O^6 & \end{array}$$

Spodumene . $$\begin{array}{ccc} & Si & \\ (\tfrac{1}{5}R^6+\tfrac{4}{5}Al) & \times & O^3 \\ & O^6 & \end{array}$$

Class 3.

Petalite . . $$\begin{array}{ccc} & Si^2 & \\ (\tfrac{1}{5}R^6+\tfrac{4}{5}Al) & \times & O^3 \\ & O^{12} & \end{array}$$

The last is the only member of Class 3 occurring in this division. The relation of petalite to spodumene and other members of the section is thus clearly shown by the new formulæ.

Normal or Unisilicates.

Class 1.

Forsterite . . . . $$\begin{array}{ccc} & Si & \\ Mg''^2 & \times & O^2 \\ & O^2 & \end{array}$$

$$= Si \,\|\, O^4 \,\|\, Mg''^2 \text{ (Dana).}$$

Fayalite . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ \mathrm{Fe''^{2}} & \times & \mathrm{O^{3}} \\ & \mathrm{O^{2}} & \end{array}$

Monticellite . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{2}\mathrm{Ca''}+\tfrac{1}{2}\mathrm{Mg''})^{2} & \times & \mathrm{O^{2}} \\ & \mathrm{O^{2}} & \end{array}$

Willemite . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ \mathrm{Zn'^{2}} & \times & \mathrm{O^{2}} \\ & \mathrm{O^{2}} & \end{array}$

Phenacite . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ \mathrm{Be''^{2}} & \times & \mathrm{O^{2}} \\ & \mathrm{O^{2}} & \end{array}$

Class 2.

Garnet . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{2}\mathrm{R^{6}}+\tfrac{1}{2}\mathrm{R})^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

$= \mathrm{Si} \,\|\, \mathrm{O^{4}} \,\|\, (\tfrac{1}{2}\mathrm{R''}+\tfrac{1}{2}\beta\mathrm{R})^{2}$ (Dana).

Grossularite . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{2}\mathrm{Ca''^{3}}+\tfrac{1}{2}\mathrm{Al})^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

Pyrope . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{2}(\mathrm{Mg''}, \mathrm{Fe''}, \mathrm{R^{2}})^{3}+\tfrac{1}{2}\mathrm{Al})^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

Almandine . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{2}\mathrm{Fe''^{3}}+\tfrac{1}{2}\mathrm{Al})^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

Epidote . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{3}\mathrm{Ca''^{3}}+\tfrac{2}{3}(\mathrm{Fe}, \mathrm{Al}))^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

Zoisite . . . . . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{1}{3}\mathrm{Ca''^{3}}+\tfrac{2}{3}\mathrm{Al})^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

Phlogopite mica . $\begin{array}{ccc} & \mathrm{Si} & \\ (\tfrac{2}{3}(\mathrm{Mg''K^{2}})^{3}+\tfrac{1}{3}\mathrm{Al})^{2} & \times & \mathrm{O^{6}} \\ & \mathrm{O^{6}} & \end{array}$

Biotite mica . $(\frac{1}{2}(\mathrm{Mg}'', \mathrm{K}^2)^3+\frac{1}{2}\mathrm{Al})^2 \overset{\mathrm{Si}}{\underset{\mathrm{O}^6}{\times}} \mathrm{O}^6$

Sarcolite . $(\frac{1}{2}(\frac{9}{10}\mathrm{Ca}''+\frac{1}{10}\mathrm{Na}^2)^3+\frac{1}{2}\mathrm{Al})^2 \overset{\mathrm{Si}}{\underset{\mathrm{O}^6}{\times}} \mathrm{O}^6$

Paranthite . . . . . $(\frac{1}{4}\mathrm{Ca}''^3+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}}{\underset{\mathrm{O}^6}{\times}} \mathrm{O}^6$

Anorthite . . . . . $(\frac{1}{4}\mathrm{Ca}''^3+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}}{\underset{\mathrm{O}^6}{\times}} \mathrm{O}^6$

Class 3.

Leucite . . . . . . $(\frac{1}{4}\mathrm{K}^6+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}^2}{\underset{\mathrm{O}^{12}}{\times}} \mathrm{O}^6$

Andesite . . . $(\frac{1}{4}(\mathrm{Ca}''\mathrm{Na}^2)^3+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{S}^2}{\underset{\mathrm{O}^{12}}{\times}} \mathrm{O}^6$

Hyalophane . . $(\frac{1}{4}(\mathrm{Ba}'', \mathrm{K}^2)^3+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}^2}{\underset{\mathrm{O}^{12}}{\times}} \mathrm{O}^6$

Oligoclase . . . $(\frac{1}{4}(\mathrm{Ca}''\mathrm{Na}^2)^3+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}^2}{\underset{\mathrm{O}^{12}}{\times}} \mathrm{O}^6$

Class 4.

Albite . . . . . . $(\frac{1}{4}\mathrm{Na}^6+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}^3}{\underset{\mathrm{O}^{18}}{\times}} \mathrm{O}^6$

Orthoclase . . . . . $(\frac{1}{4}\mathrm{K}^6+\frac{3}{4}\mathrm{Al})^2 \overset{\mathrm{Si}^3}{\underset{\mathrm{O}^{18}}{\times}} \mathrm{O}^6$

As these lists of minerals are only intended to illustrate the application of the principle of classification proposed in this paper, I have

carefully avoided entering upon doubtful questions by expressing the constitution of silicates which have been hitherto insufficiently examined.

The above arrangement of the formulæ renders remarkably evident the relations existing between the members of the felspar and other families. This group of minerals illustrates the mode of accumulation of the anhydride $\bar{S}iO^6$ upon itself without otherwise disturbing the arrangement of the molecule; and the composition of these salts appears to me forcibly to testify that *the normal rate of condensation of the acid radicle within the molecule of the silicate is three times* SiO_2, *or some simple multiple of that number.*

Basic or Subsilicates.

Class 1. Chondrodite . . . $\begin{array}{ccc} & \bar{S}i & \\ Mg''^8 & \times & O^8 \\ & O^6 & \end{array}$

$= Mg''^8\, O^2 \,\|\, O^{12} \,\|\, Si^3$ (Dana).

Class 2. Gehlenite . . $\begin{array}{ccc} & \bar{S}i & \\ (\frac{1}{2}R^6+\frac{1}{2}\bar{R})^3 & \times & O^9 \\ & O^6 & \end{array}$

Andalusite . . . . $\begin{array}{ccc} & \bar{S}i & \\ \bar{A}l^3 & \times & O^9 \\ & O^6 & \end{array}$

Topaz . . . . . $\begin{array}{ccc} & \bar{S}i & \\ \bar{A}l^3 & \times & (\frac{1}{5}Fl^2+\frac{4}{5}O) \\ & O^6 & \end{array}$

Euclase $\begin{array}{ccc} & \bar{S}i & \\ (\frac{1}{6}H^6+\frac{2}{6}Be''^3+\frac{3}{6}\bar{A}l)^3 & \times & O^{12} \\ & O^6 & \end{array}$

Probably the composition of datholite and tourmaline can be also best exhibited on a similar plan, if we regard the boric anhydride as a basic constituent. It need scarcely be said that this is a very doubtful point.

I have thus shown how readily all the silicates which mineralogists consider the representatives of great classes of anhydrous siliceous minerals can be made to fit into their proper places in the system which I have thus sketched. On this plan the oxygen ratio is the only one which we need to know in order to enable us at once to assign a satisfactory position in the series to any mineral which we may have analyzed.

It will be observed that I have not touched upon the subdivisions of the families of silicates, their general relations being all I have sought to present; nor have I entered on the consideration of many of the hydrated silicates. Both these subjects appear to require that further analytical investigations should be made before we would be warranted in offering an opinion upon either question; the function of the water in the majority of the hydrous silicates being as yet but little understood. I hope to be able at a future time to lay before the Society more details concerning the investigation an outline of which I have now had the honor of communicating.

XV.—Note on the occurrence of Anthracite in the Carboniferous Limestone of Castleknock. By Thomas J. Nicolls, Eng. Student.

[Read May 13, 1868.]

On visiting, some weeks since, the limestone district in the neighbourhood of Castleknock, for the purpose of studying its palæontological and geological features, my attention was arrested by a small isolated patch of anthracite. At a little distance it presented the appearance of a cross section of a vein; but on closer examination I found its position in the rock to be not so distinctly marked, nor, though strictly limited to the area of a few square feet, so well defined and concentrated as it at first appeared. The detached fragments—evidently from the centre of the mass—were most regular in structure, having an approximately spherical appearance, due to the number, uniformity, and smoothness of their sides. The exposed surface showed many of these still undisturbed, the interstices being filled up with smaller fragments, flakes, and dust. I observed none exceeding the size of an orange, and but two or three so large. I was prevented by the lateness of the hour from making a more minute investigation of this interesting occurrence, but was fortunate in securing some excellent specimens for the cabinet and laboratory.

Having submitted one to the examination of Mr. Jukes and Mr. Gages of the Royal College of Science, I was recommended by them to make another and more particular investigation of the locality, and to embody the results in the paper which I have the honour of submitting for your consideration.

I was enabled on the occasion of my second visit to make the following general observations:—

The anthracite occurs at a vertical depth of about 30 feet; the only mineral with which it is immediately associated is calc spar, which is abundant in veins and blocks. In the shale and irregular rock near the surface, at a distance of about 50 yards, but on a lower level than the surface overhead, are traces of galena, iron, and copper.

It is an interesting fact, that notwithstanding that the quarry has been worked through an area of a couple of acres, and to a depth, varying with the surface of the ground, as great in some places as 50 feet, yet in all that extensive excavation—about one-half of which has been effected within the last two years—no trace of the mineral has been discovered elsewhere in it by the workmen; nor did the large rock surface, which I subjected to minute examination, reveal any further indication of its occurrence.

The rock is particularly compact and solid, being consequently heavy and singularly hard; yielding lime in great quantity, which is much sought by builders on account of its binding properties. The joints are remarkably few, and the bedding very indistinct on this side of the quarry, owing to the blasting, which is the only means of removing the rock. The best instances I could select gave for the dip an angle of about 56°.

An examination of the position and appearance of the anthracite afforded the following results:—A plane of stratification is visible in the neighbourhood; but, owing to the labour bestowed on this spot, it is but faintly recognised as it reaches the mineral. This feature might suggest the probability of its being a mere deposit in the line of bedding which here assumed the nature of a cleft; or that it is a concretionary formation in a hollow existing in the rock; and the singular isolation of the specimen, and the peculiarity of its structure, would encourage such hypotheses; but they suffer when taken along with the facts that the anthracite is too local to verify the first hypothesis, and that the distinction is not immediate and decided between the anthracite and limestone, as between limestone and calc spar and chert, in either of which cases the line of demarcation is distinct. Moreover, the concretion of carbon in a carboniferous rock is, I think, not at all probable; the case not being analogous with that of silicious matter, or any other body of different constitution and affinities from those of the mass in which it is contained. From the intimate mingling, one with the other, the imperceptible transition from dusty anthracite to dusty limestone, and *vice versâ*, and the similar irregular and indistinct interstratification presented in this instance, the hypothesis which receives most support from these special appearances is that of contemporaneous formation.

It is closely associated with calc spar, which runs across it in veins, presenting, when mingling with it, a dull glassy aspect. I have two examples of slight traces of it in the spar of fossil shells—a *Productus*, and a *Producta Punctata*. In the laboratory it has resisted all attempts at fusion under the blowpipe, and has also been ineffectually subjected to the action of acids.

Of the specimens exhibited, the two lumps of pure anthracite have interest as being so perfect in form, and are exceptions to the ordinary pieces, which vary in size from that of a walnut to that of a small egg.

The next specimen is also exceptional in its characteristics, as it indicates what may be termed the fusion of the species, and shows—what

I remarked to be very rare throughout the whole bed—a peculiar lamination established on the polished surface of the limestone.

The examples exhibited of the union of the anthracite and limestone indicate perfectly the natural relation of these substances. In one the intermingling is not so well established, the lumps of anthracite (a couple of inches' thickness of which remains with the rock) are larger, and between them and the limestone is a case or coating of spar, which seems to be established in like manner round each individual lump throughout the mass, the spaces between the pieces being occupied by spar.

In the second of these instances the fusion is more complete, the characteristics of each less distinct, the particles smaller, and the spar absent, unless, as is always the case, that it occupies the cracks and spaces in the anthracite.

A third example, of this nature, from its size is more definite in its illustration; the large lumps being towards the centre of the mass, and the particles becoming smaller as they recede; till finally, on approaching the limestone, they assume the nature of dust, and so blend with the rock without any distinct indication of their junction. The spar is absent from this specimen as a distinct covering for the anthracite. This I have remarked to be always the case when the two substances are, as it were, fused into one another. On the side and back of the block, however, there are smaller nodules and particles enveloped in spar coatings, in the thickness of one of which is encased a small rhynchonella.

We come now to the examination of the last specimen exhibited; and this, if I mistake not, will prove of the greatest interest, and give rise to much speculation. It consists of a block of limestone, on one surface of which is what appears to be a broken circle of anthracite, enclosing a clayey deposit. The detection of casts on this clayey matter of concentric markings, similar to those of the *Producta Punctata*, showing the traces of the punctures, led me to the discovery of a hinge line. This is produced on the left side till it is lost and covered in the rock, and is broken on the right by a vein of spar. The clày limestone is evidently the cast of the interior of a shell; the anthracite a substitute for the organic matter which originally existed inside it. Nor is this an isolated example: I have, myself, two specimens of *Producta* in which slight traces of the anthracite occur; and a gentleman who has made this subject his study along with me has secured a specimen of *Producta* in which the space usually occupied by spar is filled altogether by anthracite.

XVI.—Sketch of a Classification of Minerals, founded on Modern Chemical Theories. By W. H. Stacpoole Westropp, M.R.I.A.

[Abstract.*]

[Read June 10, 1868.]

Classifications of Minerals are about as numerous as works on Mineralogy; every author has his own system; yet it must be acknowledged that there is no branch of science so defective in this respect; and it is a just subject for reproach, that there is no truly scientific classification of minerals, analogous to those of plants and animals. One of the great errors which has lain at the root of every classification of minerals has been the assumption that minerals in themselves constitute a complete series; any system founded on such a datum must necessarily be imperfect; minerals form only a very incomplete series; many of the gaps may be filled up by compounds prepared artificially. Just as well might a classification of the Organic Kingdom be considered perfect which did not include extinct genera and species.

In my classification, of which the following abstract is only a mere sketch, I have employed the new chemical notation. I do not think that many of the formulæ which I use are the most correct; on the contrary, some—for instance, those for the sulphates and phosphates—do not at all represent what I believe to be the true constitution of these substances.

All known chemical substances, simple and compound, inorganic and organic, are at present arranged under three great heads, called Types:—

1. HCl, Hydrochloric Acid Type.†

2. $\left.\begin{matrix}H\\H\end{matrix}\right\}O$, Water Type.

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* This paper, *as read*, was largely founded on the fourth edition of Dana's "System of Mineralogy." That great work was taken as a starting point from which to develope the changes which I thought were required by the progress of science. In the interval between the time when the paper was read and that when it should have been sent to press the fifth edition of Dana's "Mineralogy" appeared. The changes introduced in that work have been numerous and important; many of them are identical with those proposed by me, others are nearly so, others differ from them. To treat the subject properly, and to do full justice to Dana and to myself, it would have been necessary to write this paper *de novo*. To do this would have been a most agreeable task; but unfortunately circumstances occurred, and new occupations were entered into, that imperatively required nearly my whole attention—these, too, of a kind quite foreign to the study of Mineralogy. I have been able to return to the subject only at intervals—few and far between—with my mind tired and jaded from other work. This must be my apology for now giving only an abstract of my paper. I thought of withdrawing it; but this would have been doing myself an injustice.—W. H. S. W.

† This corresponds with the $\begin{matrix}H\\H\end{matrix}$ or free molecule of Hydrogen Type of some chemists.

3. $\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N$, Ammonia Type.

All bodies are supposed to be derived from one or other of these types by *substitution*; or, to speak more correctly, are built up after the same arrangement. A vast majority of minerals are formed on the Water Type. Only a few belong to the Hydrochloric Acid Type, and it is doubtful if any belong to the Ammonia Type.

CLASSIFICATION OF MINERALS, OR CHEMICAL SUBSTANCES FOUND NATIVE IN THE CRUST OF THE EARTH.

1. Elementary Bodies.

HCl Type } 2. Fluorides, Chlorides, Bromides, Iodides.

$\left.\begin{matrix}H\\H\end{matrix}\right\}O$ Type } 3. Oxides, Sulphides, Selenides, Tellurides.
4. Salts.

Elementary Bodies.

Monatomic,—Silver.
Biatomic,—Sulphur, Selenium, Tellurium, Mercury, Copper
Triatomic,—Gold.
Tetratomic,—Carbon, Tin, Iron, Lead, Platinum, Palladium.
Pentatomic,—Arsenic, Antimony, Bismuth.

Minerals formed on the Hydrochloric Acid Type.

HCl.

Rock Salt, NaCl. Bromyrite, AgBr.
Iodyrite, AgI. Yttrocerite, $(Ca,Ce,Y)_n F_n$;
also Sylvine, Salammoniac, Kerargyrite.

H_2Cl_2.

Fluor, $Ca^{ii}F_2$. Cotunnite, $Pb^{ii}Cl_2$. Calomel, Hg_2Cl_2.

H_5Cl_5.

Embolite, $Ag_5(Cl_3Br_2)^{v}$.

H_6Cl_6.

Fluellite, $Al_2^{vi}F_6$.

H_9Cl_9.

Chiolite, $(Na_3Al_2^{vi})^{ix}F_9$.

$H_{12}Cl_{12}$.

Cryolite, $(Na_6Al_2^{vi})^{xii}F_{12}$.

Minerals formed on the Water Type.

Oxygen Series.	Sulphur, Selenium, Tellurium, Series.
$\left.\begin{matrix}H\\H\end{matrix}\right\}O$ Water, H_2O Red Copper, Cu_2O Tenorite, $Cu^{ii}O$ Also Periclase, Zincite, Plumbic Ochre.	$\left.\begin{matrix}H\\H\end{matrix}\right\}X$. $X = S$, Se, or Te. H_2S, Dihydric Sulphide (Sulphuretted-Hydrogen). Ag_2S, Silver Glance. Ag_2Se, Naumannite. Ag_2Te, Hessite. Cu_2S, Copper Glance. $Cu^{ii}S$, Covelline. Also Blende, Galena, Clausthalite, Cinnabar, &c.
$\left.\begin{matrix}H_2\\H_2\end{matrix}\right\}O_2$ Pyrolusite, $Mn^{iv}O_2$ Brucite, $\left.\begin{matrix}Mg^{ii}\\H_2\end{matrix}\right\}O_2$ Quartz, $Si^{iv}O_2$ Also Rutile, Cassiterite, &c.	$\left.\begin{matrix}H_2\\H_2\end{matrix}\right\}X_2$ $Mn^{iv}S_2$, Hauerite. $\left.\begin{matrix}Pb^{ii}\\Cu_2\end{matrix}\right\}S_2$, Cuproplumbite, $\left(\left.\begin{matrix}Pb^{iv}\\Cu_4\end{matrix}\right\}S_4\ ?\right)$ $Hg^{ii}\left\{\begin{matrix}S\\Se\end{matrix}\right\}$ Onofrite. Also Pyrites, Erubescite, &c.
$\left.\begin{matrix}H_3\\H_3\end{matrix}\right\}O_3$ Arsenolite, $As^{iii}_2O_3$ Corundum, $Al_2^{vi}O_3$ And many more.	$\left.\begin{matrix}H_3\\H_3\end{matrix}\right\}X_3$ $As^{iii}_2S_3$, Orpiment. Also Stibnite and Bismuthine.
$\left.\begin{matrix}H_4\\H_4\end{matrix}\right\}O_4$ Diaspore, $\left.\begin{matrix}Al_2^{vi}\\H_2\end{matrix}\right\}O_4$ Kreittonite, $\left.\begin{matrix}(Al_2^{vi}Fe_2^{vi})_n^{vi}\\(Zn^{ii}Fe^{ii})_n^{ii}\end{matrix}\right\}O_4$ Also Spinel, and many more.	$\left.\begin{matrix}H_4\\H_4\end{matrix}\right\}X_4$ $\left.\begin{matrix}Fe_2^{vi}\\Cu_2\end{matrix}\right\}S_4$, Chalcopyrite. $\left.\begin{matrix}Co_2^{vi}\\(Cu_2Co^{ii}Fe^{ii})_n^{ii}\end{matrix}\right\}S_4$, Linnæite. Also Siegenite.

The foregoing list does not contain Breithauptite, NiSb; Leucopyrite, $FeAs_2$; or Mispickel; on hypothetical grounds, which would take up too much space to explain, I believe these minerals, and others of the same class, may be correctly represented thus:—

Breithauptite, $Ni^{ii}_2Sb_2^{iii}$.
Leucopyrite, $Fe^{ii}As_2^{i}$.
Mispickel, $Fe^{ii}_2S^{ii}_2As^{v}_2$.

Tabular Arrangement of General Formulæ for Salts.

Oxygen Series.	Sulphur Series.
$\left.\begin{matrix}H\\H\end{matrix}\right\}O$ Nitrates (?) $\left.\begin{matrix}NO_2^{i}\\M\end{matrix}\right\}O$	$\left.\begin{matrix}H\\H\end{matrix}\right\}S$
$\left.\begin{matrix}H_2\\H_2\end{matrix}\right\}O_2$ Sulphates, Selenates, Chromates, Tungstates (?) $\left.\begin{matrix}RO_2^{ii}\\M_2\end{matrix}\right\}O_2$ Carbonates (?) $\left.\begin{matrix}CO^{ii}\\M_2\end{matrix}\right\}O_2$ Oxalates, $\left.\begin{matrix}C_2O_2^{ii}\\M_2\end{matrix}\right\}O_2$	$\left.\begin{matrix}H_2\\H_2\end{matrix}\right\}S_2$
$\left.\begin{matrix}H_3\\H_3\end{matrix}\right\}O_3$	$\left.\begin{matrix}H_3\\H_3\end{matrix}\right\}S_3$ $\left.\begin{matrix}R^{iii}\\M_3\end{matrix}\right\}S_3$ Ortho-salts. $\left.\begin{matrix}R^{iii}_2\\M_4\end{matrix}\right\}S_5$ Para-salts. $\left.\begin{matrix}R^{iii}\\M\end{matrix}\right\}S_2$ Meta-salts. Sulph-arsenites, antimonites, bismuthites.
Phosphates, Arsenates, Antimonates, Vanadates, Tantalates, Nitrates (?) Ortho-salts $\left.\begin{matrix}RO^{iii}\\M_3\end{matrix}\right\}O_3$ Para-salts $\left.\begin{matrix}RO^{iii}_2\\M_4\end{matrix}\right\}O_5$ Meta-salts $\left.\begin{matrix}RO^{iii}\\M\end{matrix}\right\}O_2$	$\left.\begin{matrix}RS^{iii}\\M_3\end{matrix}\right\}S_3$ Ortho-salts. $\left.\begin{matrix}RS_2^{iii}\\M_4\end{matrix}\right\}S_5$ Para-salts. $\left.\begin{matrix}RS^{iii}\\M\end{matrix}\right\}S_2$ Meta-salts. Sulph-arsenates, antimonates, bismuthates.
$\left.\begin{matrix}H_4\\H_4\end{matrix}\right\}O_4$ Carbonates (?), Titanates (?), Metasilicates, Meta salts $\left.\begin{matrix}R^{iv}\\M_2\end{matrix}\right\}O_3$ Orthosilicates, $\left.\begin{matrix}Si^{iv}\\M_4\end{matrix}\right\}O_4$	$\left.\begin{matrix}H_4\\H_4\end{matrix}\right\}S_4$ $\left.\begin{matrix}Sn^{iv}\\M\end{matrix}\right\}S_4$ Sulph-ortho-stannate. as $\left.\begin{matrix}Sn^{iv}\\Fe^{ii}Cu_2\end{matrix}\right\}S_4$ Tin Pyrites.

GENERAL SUMMARY OF SALTS.

Nitrates.—These minerals do not require any particular remarks.

Sulphates.—All the anhydrous sulphates are represented by the general formula, $\left.\begin{matrix}SO_2^{ii}\\M_2\end{matrix}\right\}O_2$. Out of twenty-four hydrous sulphates, sixteen are ortho-salts, and may be represented by the general formula, $\left.\begin{matrix}SO_2^{ii}\\M_2\end{matrix}\right\}O_2+nAq$. The other eight are derived from condensed acids. We cannot be sure of the true formulæ for these until they shall have been examined upon the principles which will be referred to when describing the hydrous silicates. These remarks apply also to all other hydrous salts, such as hydrous phosphates, carbonates, and especially borates.

Borates.—I am not at all sure that the true relations of boric acid are as yet thoroughly understood; this, together with the fact that most of the borates are hydrous, prevents my saying anything about them.

Carbonates.—All the anhydrous carbonates are ortho-salts of the type $\left.\begin{matrix}CO^{ii}\\M_2\end{matrix}\right\}O_2$.

Out of fourteen hydrous carbonates, five may be ortho-salts; the others are of doubtful constitution.

Sulph-Arsenites, &c.—The general formula, $\left.\begin{matrix}R^{iii}\\M\end{matrix}\right\}S_2$ represents what has been called a meta-salt; it includes wolfsbergite, tannenite, and three more.

$\left.\begin{matrix}R^{iii}\\M_3\end{matrix}\right\}S_3$ represents an ortho-salt: pyargyrite, proustite, and four more belong to this group.

$\left.\begin{matrix}(R^{iii})_2\\M_4\end{matrix}\right\}S_5$ represents a para-salt; it includes heteromorphite, and three more.

The few other minerals belonging to this class can be readily shown to be derived from condensed sulphacids. I have prepared a complete list of them.

Phosphates, Arsenates, &c.—All the anhydrous phosphates are ortho-salts; some are mixed with salts belonging to the HCl type. They may be grouped under three heads:—

$\left.\begin{matrix}RO^{iii}\\M_3\end{matrix}\right\}O_3$ includes tryphylline, and four more.

$\left.\begin{matrix}RO^{iii}\\M_3\end{matrix}\right\}O_3+MF$ represents wagnerite.

$\left(\begin{matrix}RO^{iii}\\M_3\end{matrix}\Big\}O_3\right)_3 + MX$, where X signifies F or Cl, includes apatite, mimetine, and two more.

Out of twenty hydrous phosphates and arsenates, nine may be represented by the general formula, $\begin{matrix}RO^{iii}\\M_3\end{matrix}\Big\}O_3 + nAq.$; seven by $\begin{matrix}RO^{iii}\\M_5\end{matrix}\Big\}O_4 + nAq.$; and six by $\begin{matrix}(RO^{iii})_2\\M_{12}\end{matrix}\Big\}O_9 + nAq.$ (See remarks on hydrous sulphates).

Sulph-Arsenates, &c.—Plagionite, freislebenite, and kobellite, are, perhaps, sulphosalts of condensed acids of this series.

I have now given a short sketch of the relations of the most important minerals, except the silicates. The correlation of the oxygen with the sulphur series is particularly instructive; and, from partial examination of their crystallographic characters, I am inclined to think that further analogies will be proved to exist between them than merely in chemical composition. Before entering into a description of the important class of silicates, it will be necessary to make a few remarks. I was so much astonished lately at hearing a high authority express the opinion that SiO_3 was preferable to SiO_2, as the formula for silica, that I intended to enter fully into the arguments upon which the latter formula is founded; but Dr. Emerson Reynolds has informed me that he has discussed the matter fully in his paper, and has given both sides of the question. So it will not be necessary to do more than allude to it. To me the results obtained from the calculation of the densities of silicic chloride and silicic fluoride, as obtained by experiment, appear conclusive; but the researches of Ebelmen and MM. Friedel and Krafts on silicic ethers have settled the matter beyond question; for these gentlemen have succeeded in replacing one, two, three, or four atoms of chlorine in silicic chloride by one, two, three, or four equivalents respectively of monatomic compound radicles, such as ethyl, methyl, &c.; as well as by forming synthetically numerous other organic compounds of silica; and these experiments, one and all, have conclusively established the tetratomicity of silicon.

It was in the year 1864 that I began to project a revised classification of minerals; and among the first which I attacked were those which are most interesting to geologists—the silicates. I then constructed a very imperfect and fragmentary classification of these minerals, on the supposition that they were derived from condensed acids.*

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* At the meeting at which this paper was read, I exhibited tables of condensed Silicic Acids, one copied from Naquet's excellent "Principes de Chimie;" the other constructed by myself on a different principle. It would be out of place to occupy the pages of this Journal by printing these tables, which are of purely hypothetical chemical interest.

By a lucky chance, in the winter of 1864–5, I happened to attend the lectures on chemistry, delivered in the then Museum of Irish Industry, now the Royal College of Science, by my friend Professor W. K. Sullivan. I was not a little surprised to find that he had given in the admirably prepared syllabus of the course the formulæ of a very large number of the silicates, worked out on precisely the same principle, and very nearly so in detail, as I had attempted to do independently. So far as I am aware, this syllabus was the first printed of anything like a complete list of silicates, founded on the modern theories. Previously, however, Dr. Olding, in a well-known paper in the "Philosophical Magazine" (vol. xviii.), had applied the new formulæ to a few silicates.

With regard to formulæ, it really matters very little what kind we use; they are merely representations of facts from particular points of view. Facts are unalterable, but our modes of looking at them are constantly changing, and probably the formulæ of twenty years hence will differ as much from those now in use as do these latter from those of twenty years ago; for instance, water has had, and will always have, the same composition: it contains two volumes of hydrogen to one volume of oxygen, or eight parts by weight of oxygen to one part by weight of hydrogen. Now, we cannot change this *fact*, yet we may write the formula of water as HO, or OH, or H_2O, or $O\left\{\begin{matrix}H\\H\end{matrix}\right.$, or $\left.\begin{matrix}H\\H\end{matrix}\right\}O$, or HOH; and any one of these will appear more correct than the others according as we change the point of view from which we regard the fact.

ANHYDROUS SILICATES.

Out of fifty-four anhydrous silicates, which I have carefully examined, twenty-four are derived from ortho-silicic acid, $\left.\begin{matrix}Si^{iv}\\H_4\end{matrix}\right\}O_4$, or from multiples of it, $\left(\left.\begin{matrix}Si^{iv}\\H_4\end{matrix}\right\}O_4\right)_n$; of these, nine, including chrysolite, zircon, gadolinite, have the formula, $\left.\begin{matrix}Si\\R^{ii}{}_2\end{matrix}\right\}O_4$. Five, including garnet, idocrase, and biotite, have the formula, $\left\{\begin{matrix}Si_3\\R^{vi}{}_2R^{ii}{}_3\end{matrix}\right\}O_{12}=\left(\left.\begin{matrix}Si\\R_4\end{matrix}\right\}O_4\right)_3$. Anorthite, lepidomelane, and three more, have the formula, $\left\{\begin{matrix}Si_2\\R_2{}^{vi}R^{ii}\end{matrix}\right\}O_8=\left(\left.\begin{matrix}Si\\R_4\end{matrix}\right\}O_4\right)_2$. The remaining six are derived from ortho-silicic acid in a similar manner.

Thirteen anhydrous silicates are derived from the first condensed acid, or, as it is sometimes called, meta-silicic acid, $\left.\begin{matrix}Si\\H_2\end{matrix}\right\}O_3$, or from multiples of it, $\left(\left.\begin{matrix}Si\\H_2\end{matrix}\right\}O_3\right)_n$.

$$\left.\begin{array}{l}\text{Wollastonite,}\\ \text{Augite,}\\ \text{Hornblende} + H_2O,\end{array}\right\} \left.\begin{array}{c}Si\\ R^{ii}\end{array}\right\} O_3.$$

$$\left.\begin{array}{l}\text{Spodumene,}\\ \text{Oligoclase ?*}\end{array}\right\} \left.\begin{array}{c}Si_{15}\\ (R_2{}^{vi})_4 R^i{}_6\end{array}\right\} O_{45} = \left(\left.\begin{array}{c}Si\\ H_2\end{array}\right\} O_3 \right)_{15}.$$

$$\text{Beryl,} \quad \left.\begin{array}{c}Si_6\\ R_2{}^{vi} R^{ii}{}_3\end{array}\right\} O_{18} = \left(\left.\begin{array}{c}Si\\ H_2\end{array}\right\} O_3 \right)_6.$$

The remaining silicates of this group are derived from meta-silicic acid in a similar manner.

Of the silicates derived from other condensed acids, or their multiples, I shall give two illustrations :—

$$\left.\begin{array}{l}\text{Albite,}\\ \text{Orthoclase,}\end{array}\right\} \left.\begin{array}{c}Si_6\\ R_2{}^{vi} R_2\end{array}\right\} O_{16} = \left(\left.\begin{array}{c}S_3\\ R_4\end{array}\right\} O_8 \right)_2.$$

$$\left.\begin{array}{l}\text{Lepidolite,}\\ \text{Labradorite,}\end{array}\right\} \left.\begin{array}{c}Si_3\\ R_2{}^{vi} R^{ii}\end{array}\right\} O_{10} = \left.\begin{array}{c}Si_3\\ R_8\end{array}\right\} O_{10}.$$

I have prepared the formulæ of all the anhydrous silicates on the above principle, and they can be shown to be derived from a very small number of condensed acids. One group, however, including andalusite, topaz, kyanite, euclase, and sphene, appears to be derived from multiples of an acid, which cannot strictly be called condensed, having the formula, $\left.\begin{array}{c}Si\\ H_6\end{array}\right\} O_5$.

Fellows may remember that, at the last meeting of this Society, Dr. Reynolds explained some new formulæ for silicates, which have been proposed by Dana. So recently as this day-week (June 10, 1868), at Council meeting, Dr. Reynolds spoke to me about them, and told me they were to be found in the "American Journal of Science" for last year. On looking into it I find that Dana has been writing a series of papers, which had altogether escaped my notice. In them he gives a sketch of the principles he will adopt in a new edition of his "System of Mineralogy," now, I believe, in the press.†

In this new edition of his work on Mineralogy it will be seen that Dana "accepts" the modern chemical theories, and has given up the formula SiO_3 as no longer tenable. Much as I am rejoiced at this, I cannot conceal my disappointment that he has adopted a mode of writing formulæ which is so complicated as to be almost unintelligible. He thinks that all silicates can be classed into what he calls unisilicates,

* This formula for oligoclase is only approximate. On a future occasion I hope to be able to give its true formula in a paper on the Feldspars, and their relations to other silicates.

† Since published. This is the fifth edition mentioned in the note at the beginning of this paper ; it is really rather a new work than a new edition.

bisilicates, subsilicates, or intermediate silicates. How this is done I shall not attempt to explain, but shall merely quote a few of his formulæ for illustration.

$$\text{Fosterite, Si} \mid O_4, \mid Mg_2.$$

This appears simple enough, but look at two others, certainly extreme cases:—

$$\text{Astrophyllite, Si} \mid O_4 \mid (\tfrac{10}{17}(R_2, R) + \tfrac{3}{17}\beta R + \tfrac{4}{17}\gamma (Ti, Zr))_2.$$

$$\text{Hisingerite, Si} \mid O_4 \mid (\tfrac{1}{3}H_2 + \tfrac{2}{3}(R, \beta Fe))_2 + \tfrac{4}{3} Aq.$$

Now, objectionable as were Dana's older formulæ, far worse as were the *hideous* (I cannot find any other word to convey my opinion of them) and useless formulæ of Rammelsberg, I hope we have reached the climax of unintelligibility in these new formulæ of Dana. Look at one specimen what he calls an intermediate silicate:—

$$Si \mid O_4 \mid (\tfrac{1}{8} Na_2 + \tfrac{3}{8}\beta Al + \tfrac{4}{8}\gamma Si)_2$$

Would anybody suppose that this is only our old friend albite? Were I at a loss how to explain what I believe to be the very great simplicity and, may I say, superiority of the notation (it is not my own) used in this paper, a better way could not be found than by comparing my formula of this mineral with that of Dana. On looking into my list* of silicates, albite will be found under the head of the type $\left(\left.\begin{matrix}Si_3\\H_4\end{matrix}\right\} O_8\right)_n$. Now, before going further, here is a great fact—the ratio of the silicon to that of the metals is as three to four; this is shown in whole numbers, without any of those tantalizing fractions which upset all our notions of the indivisibility of atoms; on examining albite in particular we find that the acid from which it is derived is $\left(\left.\begin{matrix}Si_3\\H_4\end{matrix}\right\} O_8\right)^2$ $= \left.\begin{matrix}Si_6\\H_8\end{matrix}\right\} O_{16}$. Now we have to see how the H_8 is replaced by metals: a discussion of the analysis shows that six atoms of hydrogen are replaced by one double atom of aluminium, which is hexatomic, and the other two by two atoms of monatomic sodium, so that the formula for albite is $\left.\begin{matrix}Si_6\\Al_2{}^{vi}Na_2\end{matrix}\right\} O_{16}$†. Could anything surpass this in clearness, precision, and above all, simplicity?

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* This refers to the complete table of formulæ prepared by me, which, if printed, would occupy perhaps as much space as the whole of this paper.

† Some may prefer the formula written *on* the line thus:—$Si_6 O_{16} Al_2{}^{vi} Na_2$; this would require the Water Type to be written HOH, instead of $\left.\begin{matrix}H\\H\end{matrix}\right\} O$. The form HOH has many arguments in its favour.

Having worked out the foregoing principles with regard to the silicates, I applied them to the sulphates, phosphates, &c., with equally satisfactory results.

The preceding summary does not include the hydrous silicates. It is doubtful if we are yet in possession of sufficient data upon which to found a correct classification of these interesting minerals; they require extended experimental examination. Dr. Reynolds, I am happy to say, has hinted that he is likely to take them under his charge; they could not be in more careful or competent hands. It may be well, however, to throw out some hints as to points that should be considered, which, if they have not already suggested themselves, may be of use to those who are about to conduct experimental investigations.

If magnesium sulphate be crystallized at 15° Centigrade, it assimilates seven molecules of water of crystallization; if, however, it is made to crystallize at 0° Centigrade, it takes up twelve molecules of water; while, by varying the temperature of the solution during crystallization between these points, it can be obtained with varying amounts of water of crystallization.

If ferrous sulphate ($SO_4Fe^{ii} + 7$ Aq.) be heated moderately, six molecules of water may be driven of; but a temperature nearly sufficient to decompose the salt is required in order to eliminate the seventh molecule of water. Moreover, this latter can be replaced by an alkaline sulphate, whence we get a salt having the following composition :—

$$S_2O_8Fe^{ii}K_2 + 6 \text{ Aq.}; \text{ or, } SO_4Fe^{ii} + SO_4K_2 + 6 \text{ Aq.}$$

In tribasic phosphoric acid (PO_4H_3), one, two, three atoms of hydrogen can be replaced by one, two, three atoms respectively of a monatomic metal. If this acid be heated to about 214° Centigrade, it becomes converted into pyrophosphoric acid ($P_2O_5H_4$). No amount of heat can drive away the third atom of hydrogen; but the acid (PO_2H, metaphosphoric acid) can be obtained by other means.

Hypophosphorous acid (PO_2H_3)) is, on very plausible grounds, supposed by M. Lieben to be $\left.\begin{matrix}POH_2\\H\end{matrix}\right\}O$.

Here are four cases, in each of which water (or hydrogen, or hydroxyl) exists under different circumstances :—

1. In magnesium sulphate it is *water of crystallization,* but varying in amount with the temperature at which the salt crystallizes.

2. In ferrous sulphate six molecules of water are water of crystallization; the seventh has been called *saline water.*

3. In phosphoric acid the *water is basic.*

4. In hypophosphorous acid, if we accept M. Lieben's view, some of the water appears to be *water of constitution,* which cannot be expelled without decomposing the compound.

Water in hydrous silicates may exist in any or all of these conditions. Practically, I think, they will probably resolve themselves into two—water of crystallization and basic water.*

Some observations made by Dr. Reynolds at past meetings tend to confirm the old view that in apophyllite, at least, some of the water may be basic.

Experiments conducted from this point of view may lead to results which may be of not a little geological interest; for instance, if we find that when a certain hydrous silicate is heated up to a certain temperature, it begins to lose its water, we may assume that it could not have been formed at a higher temperature (pressure to be taken into consideration); but, when we find another mineral, almost similar to the last in every respect, except that it contains a larger quantity of water, may we not safely assume that it might have been produced at a lower temperature, the precise amount to be determined by experiment?

Thus we may indulge in the speculation that a basalt, or other volcanic rock, containing hydrous silicates, is like a self-registering thermometer, and that, as it cooled, different minerals were developed in it; and we may be able not only to arrive at an idea of the order of succession in which they were formed, and say that such and such a mineral was produced before a different one, and after another, but even to make an estimate of the temperature at which it was formed.

It is unnecessary to say, that this is a mere speculation, and as such must be valued; but I venture to think that, by bearing it in mind, experimentalists may possibly arrive at interesting, perhaps even unexpected results.

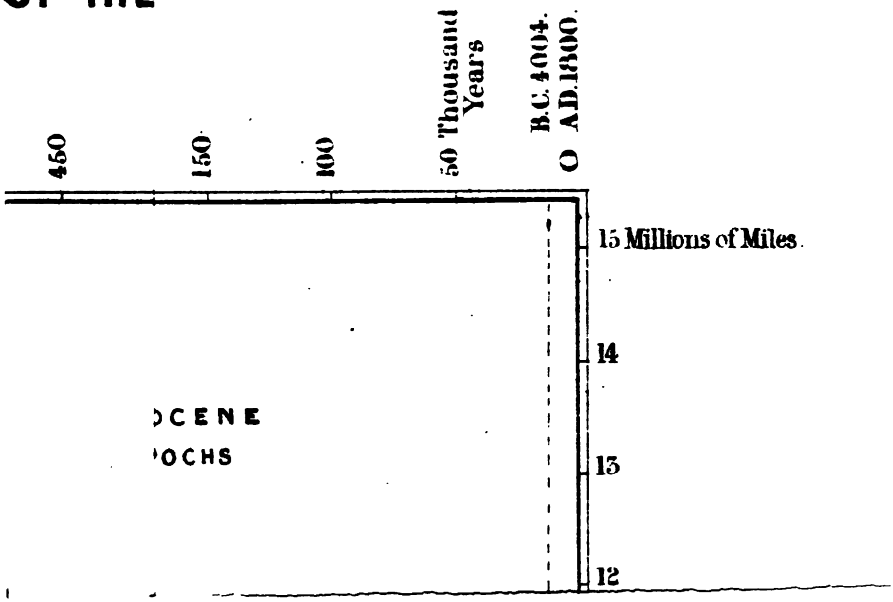
XVII.—On the Chronology of the Tertiary Epoch. By J. Scott Moore, Esq. (With two Plates.)

[Read November 11, 1868.]

The diagrams appended to this volume of the "Journal" are intended to illustrate the variations in the eccentricity of the earth's orbit, as calculated by Mr. Croll, and as applied by Mr. J. Scott Moore, to explain the various supposed tertiary glacial epochs. Diagram No. 1 exhibits the degrees of varying eccentricity for the million years preceding A.D. 1800, and it will be seen that the periods of greatest eccentricity are represented by ascending lines, and those of least eccentricity by the descending lines. Mr. Moore suggests that the period of greatest orbital eccentricity, which occurred 850,000 years before 1800, as calculated by Leverrier and Lagrange's formulæ, corresponded to that part of the Miocene age in which traces of glacial action have been found. Mr. Moore also suggests that the period of high eccentricity, beginning 50,000 years

* I see that almost similar speculations have suggested themselves to Dana. (See "Sys. of Min.," 5th ed., p. 393.)

OF THE


450
150
100
50 Thousand Years
B.C. 4004.
O A.D. 1800.
15 Millions of Miles.
14
13
12
OCENE
OCHS

back, and extending over the 200,000 years before that time, corresponded to the Pleistocene Glacial epoch.

Diagram No. 2 represents on a larger scale this later period of high eccentricity and glacial action.

XVIII.—On the Theory of Secondary Joints, as illustrated by Mr. Hull's Paper on the Lines of Elevation of the Pendle Hills, in Lancashire. By the Rev. Samuel Haughton, M. D., D. C. L., Fellow of Trinity College, Dublin.

[Read December 9, 1868.]

In a paper read before the Geological Society of London in April, 1868, Mr. Hull has described the following Lines of Elevation as occurring in the Carboniferous Rocks of Lancashire.

" 1st, and Earliest (*Pendle System*), E. N. E. direction; at the close of the Carboniferous period.

2nd, next (*Pennine System*), N. S. direction, nearly; at the close of the Permian period.

3rd, and latest (Lines of fracture), N. N. W. direction; at the close of the Jurassic period."

These axes of elevation and lines of fracture form so simple an illustration of my system of Primary, Conjugate, and Secondary Joints, that I believe a few lines in explanation of them are worthy of the attention of the Royal Geological Society.

The Pendle and Pennine systems make an angle of 86° with each other, and may be regarded as the Primary and Conjugate systems of the North of England. The third, or post-Jurassic system, makes an angle of 34° with the Pennine system, and is to be considered as one of the secondary systems, explained in my paper on the Joint Systems of Ireland and Cornwall, read before the Royal Society in 1864.

I have shown in that paper that Secondary Joints, forming angles from 30° to 26° with the Primary Joints, are the necessary consequence of mechanical forces acting on rock masses, in which the angle of friction ranges from 30° to 38°; and that the entire system of Primary, Conjugate, and Secondary Joints, occurring in any district, is an easy consequence of the *same system* of forces acting upon that district; and by no means necessitates the hypothesis of distinct sets of forces for each system of faults or axes.

The system of forces that produced the Lancashire axes acted in a N. S. direction; causing, firstly, the Pendle or Primary axis of elevation; secondly, the Pennine, or Conjugate axis of elevation; and, lastly, the Lines of Fracture, or post-Jurassic system of joints.

Thus the observed geological order of occurrence of these systems, determined by Mr. Hull, coincides with the order that might have been predicted from the action of mechanical forces.

The angles between the Primary and Secondary Joints of Waterford, Donegal, Mourne, Fermanagh, and Cornwall, range from 27° 15′ to 37° 11′.

XIX.—Note on Specimens of Rutile, from the County Mayo. By J. Emerson Reynolds, L. R. C. P., Keeper of the Minerals and Analyst to the Royal Dublin Society.

[Read December 9, 1868.]

In the month of August, 1868, some splendid crystals of Rutile were discovered by Spencer G. Perceval, Esq., of Bristol, in beds of mica slate occuring in the mountain Cush-Cum-Curragh, situated on the north shore of Clew Bay, county Mayo. Some of the finest specimens were presented by Mr. Perceval to the Royal Dublin Society; and this gentleman was likewise so good as to give me several fragments of the mineral for chemical examination.

Since one of the specimens is probably the largest crystal of this comparatively rare oxide of titanium which has been yet obtained in the British isles, I now venture to lay this brief note upon the discovery before the Society.

As already stated, the Rutile was found imbedded in mica slate, and was accompanied by schorl, minute crystals of garnet, and, according to Mr. Perceval, by andalusite likewise. The largest of the specimens obtained—that now in the mineral collection of the Royal Dublin Society—is partially imbedded in the rock, and measures four inches in length, by $\frac{3}{4}$ inch in breadth; but since the long dimetric prism of the mineral has each termination hidden by the rock which it pierces, there is good reason for believing that the length of the crystal is really greater than that stated above. The chief part of the exposed surface of the prism has a micaceous coating, but where the latter is deficient the mineral is seen to have a fine, reddish-brown colour, and the well known metallic-adamantine lustre of Rutile. A minute fragment gave the titanium reaction with tin in the reducing flame of the blowpipe, and a portion of another precisely similar, but much smaller crystal, when powdered and fused with acid sulphate of potassium dissolved completely. The aqueous solution of this fused mass, when boiled for some time, gave the well known yellowish white precipitate of titanic acid. There can, therefore, be no doubt as to the identity of the mineral.

A fragment was found to have the specific gravity, 4·23. An analysis of a good specimen of the Rutile dried at 150 C. gave the following results:—

TiO_2, ...	97·88
Fe_2O_3, ...	1.79
	99·67

Amongst the specimens given to me by Mr. Perceval, I found some small crystals identical in form with the rutile, but quite black. Analysis proved this mineral to be rutile also, but corresponding to the

variety called *nigrine* by some mineralogists. Though the amount of material at my disposal was too small to enable me to obtain very satisfactory evidence of the condition of the iron also present in this variety, I am warranted in stating that a portion of the iron is present, as *ferrosum*, or in its lowest state of oxidation, while in the red variety of the Rutile all the iron is present, as *ferricum* or peroxide of iron. This appears to be the only difference between the two minerals, and the probability of the truth of this suggestion is strengthened when we recollect that Magnetite or magnetic oxide of iron is often found imbedded in minute grains in the dark Rutile crystals.

The occurrence of Magnetite under such circumstances has been thought strange by Kersten and others; but it appears to admit of easy explanation if we grant the possibility of the Rutile containing peroxide of iron coming in contact with a minute quantity of any reducing agent, such as sulphurous acid, sulphuretted hydrogen, or organic matters; for we know that

$$3(Fe_2O_3) - O = 2\left(\begin{array}{ccc} & Fe^2 & \\ Fe & \times & O \\ & O_3 & \end{array}\right).$$

Since the black magnetic oxide of iron so produced readily assumes the crystalline form, and is not isomorphous with the Rutile, we might reasonably anticipate that a considerable proportion of the iron would separate from the latter as Magnetite, in more or less modified octohedrons of the monometric system.*

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* In connexion with the occurrence, stated above, of one of these varieties of titanic acid in a metamorphic rock which may have been subjected to a high temperature, I may note some remarkable results obtained by Hautefeuille in his synthetic researches on minerals. When a mixture of gaseous fluoride of titanium and steam was passed through a tube heated to the boiling point of cadmiun (nearly 400° C), dimetric octohedrons of *Anatase* were produced. When the tube was heated to about the boiling point of zinc (1040° C, according to Deville and Troost), *Brookite* was deposited in its usual trimetric octohedrons, while at a bright cherry-red heat only dimetric prisms of *Rutile* separated. May not the particular form in which we find titanic acid crystallized in a rock afford us some information as to the temperature to which the mass has been subjected? Hautefeuille does not appear to have considered this possible bearing of his experiments.

XX.—Notes of a Comparison of the Granites of Cornwall and Devonshire with those of Leinster and Mourne. By the Rev. Samuel Haughton, M. D., D. C. L., F. R. S., Fellow of Trinity College, Dublin.

[Read December 9, 1868.]

The Granites of Mourne are eruptive, and can be proved to contain albite in their second felspar.

The Granites of Leinster are also eruptive, and although albite has never yet been actually found to occur in them, its existence can be inferred with considerable probability.

During the past summer (1868) I have succeeded in proving that the second felspar that occurs in the Granites of Cornwall is albite. I found this mineral as a constituent of the Granite at Trewavas Head, where it has the following composition :—

I. *Albite*, var. *Cleavelandite* (*Trewavas Head*).

Silica,	65·76
Alumina,	21·72
Lime,	0·89
Magnesia,	trace
Soda,	9·23
Potash,	1·76
Water,	0·40
	99·76

This albite is opaque, cream-coloured, lamellar, and associated with quartz and orthoclase, which has the following composition :—

II. *Orthoclase* (*Trewavas Head*).

	No. 1.*	No. 2.†
Silica,	63·60	63·20
Alumina,	21·04	21·00
Iron and manganese oxides,	trace	trace
Lime,	0·90	0·68
Magnesia,	trace	trace
Soda,	3·08	2·75
Potash,	9·91	10·30
Water,	0·40	0·40
	98·93	98·33

The Granites of Cornwall and Devon contain two micas, white and black. I was fortunate enough to obtain, through my friend Mr. W. J. Henwood, F. R. S., of Penzance, a sufficient quantity of white mica from Tremearne, near Trewavas Head, to determine accurately its com-

* From veins at foot of cliff associated with Cleavelandite albite.

† From the Granite at summit of cliff.

position, which proves to be highly interesting. It differs essentially from the white mica of Leinster and Donegal, and proves to be a variety of lepidolite.

III. *White Mica, Lepidolite (Tremearne, near Trewavas Head).*

Silica, SiO_2,	47·60
Fluosilicon, SiF_3,	5·68
Alumina,	27·20
Iron peroxide,	5·20
Manganese protoxide,	1·20
Lime,	0·45
Magnesia,	trace
Potash,	10·48
Soda,	0·72
Lithia,	1·14
	99·67

This lepidolite is white, pearly, and occurs in rhombic tables of 60° and 120°. Its oxygen ratios are, reckoning for the fluorine its equivalent of oxygen—

Oxygen Ratios.

Silica,	24·714	26·461	8·9
Fluosilicon,	1·747		
Alumina,	12·713	14·270	4·8
Iron peroxide,	1·557		
Manganese protoxide,	0·268	2·982	1·0
Lime,	0·127		
Magnesia,	—		
Potash,	1·776		
Soda,	0·184		
Lithia,	0·627		

This corresponds with a theoretical formula, in which the oxygen of the silica is to that of the bases as 3 : 2.

The Black Mica of the Cornish Granites seems to be more abundant than the White Mica already described. I found a sufficient quantity of it at Carn Bosavern, near St. Just, to enable me to make the following analysis :—

IV. *Black Mica, Lepidomelane (Coron Bosavern, near St. Just).*

Silica (SiO_2),	39·92
Fluosilicon (SiF_3),	3·04
Alumina,	22·88
Iron peroxide,	15·02
Iron protoxide,	2·32
Manganese protoxide,	1·40
Lime,	0·68
Magnesia,	1·07
Potash,	9·76
Soda,	0·99
Lithia,	1·71
	98·79

The Black Mica of St. Just is of a blackish-bronze colour and metallic lustre, and occurs in rhombs of 60° and 120° angles. Its oxygen ratios are, reckoning for the fluorine its equivalent of oxygen—

Oxygen Ratios.

Silica,	20·727	21·645
Fluosilicon,	0·918	
Alumina,	10·692	15·092
Iron peroxide,	4·400	
Iron protoxide,	0·514	4·292
Manganese protoxide,	0·310	
Lime,	0·192	
Magnesia,	0·427	
Potash,	1·655	
Soda,	0·254	
Lithia,	0·940	

The oxygen ratio of this iron-potash Mica (which is undoubtedly a lepidomelane) for silica and bases is

216 : 194, or 1 : 1.

The Granites of Cornwall and Devon, which have been frequently examined by me during the last sixteen years, appear all to contain the two felspars and the two micas above analyzed. In a future communication I hope to describe their composition in detail, and give a comparison of this composition with that of the Granites of Ireland.

The following generalizations will be found, as I believe, capable of proof:—

(1) The Granites of Ireland may be divided into two distinct classes, marked by characters both geological and mineralogical.

(2) The First Class of Granites consists of Eruptive rocks, of ages varying from the Silurian to the Carboniferous periods. To this class may be referred the Granites of Leinster and Mourne, and the Granites of Cornwall and Devon.

(3) The First Class of Granites is characterized by the presence of orthoclase and albite, and by the absence of all the Lime Felspars.

(4) The Second Class of Granites consists of Metamorphic rocks, of unknown geological age, but probably subsequent to the Laurentian period. To this class may be referred the Granites of Donegal and Galway, and the Granites of Scotland, Norway, and Sweden.

(5) The Second Class of Granites is characterized by the presence of orthoclase and oligoclase, or Labradorite, or some other of the Lime Felspars, and by the absence of albite.

XXI.—Letter from Mr. G. V. Du Noyer, G. S. I., on the Flint Flakes of Antrim and Down.

(Plate XIII.)

[Read January 13, 1869.]

Antrim, 18*th December*, 1868.

Sir,—Through the kindness of Sir Roderick Murchison, Bart., our Director-General, I am enabled to present a collection of worked flint flakes, from the stratified sand and gravel, to the Museum of the Society.

These singular relics are found in great abundance in the districts of Belfast, Larne, and Carrickfergus, in the County Antrim; and Holywood and Bangor, in the County Down. Associated with them are rounded lumps and pebbles of chalk, pierced by lithophagi, and also marine shells of the ordinary type. Usually these flakes occur near the upper surface of the drift gravel; but at Ballyholine Bay, near Bangor, they are found at a depth of six to eight feet from the soil, in stratified sand and gravel.

The flint flakes forming this collection were procured by myself during my geological work over the districts named.

I may remark that, when these singular flakes were first discovered in the district around Carrickfergus, about five years since, their mechanical origin was questioned. Indeed, I myself thought at first that they were due to the crushing by natural causes (the weight of the basalt) of the flint nodules, forming the original drifts over the atmospherically eroded surface of the chalk. The chippings around the edges of the flakes can, however, only be accounted for by artificial means, as they afford clear evidence of design in their forms and mode of occurrence.

Subsequent examination clearly showed me that every flake, no matter how rude its form, or how sharp its edge, exhibited at one end a flat surface, transverse to the longest axis of the flake, and from this surface a blow was given at a *point* on it, which caused a flake to come off from the original nodule, and this flake, below the point of concussion, exhibited a conchoidal fracture, and a "bulb of concussion," features which could only be formed by, and were, the result of "an intelligent blow."

I have succeeded in making a flake of this primary form, which I illustrate by a flake of the same character, from drift sand and gravel on the west shore of Island Magee, County Antrim.

If you will procure some specimens, illustrative of the manufacture of gun flints at the present day, the full force of the reasoning I have put forward will be at once apparent.

On the east shore of Island Magee, I found a horde of these subsoil flint flakes, which are characterized by the fresh appearance they present, and which want that white crust of kaolin, which the flakes from the marine drift almost invariably present.

Though these subsoil flakes have a recent look, their surfaces possess

that porcellanic glaze characteristic of the flints from the drift of the Valley of the Somme, and those from the English drift, which no freshly manufactured flint could ever have.

The edges of these subsoil flakes are often as sharp as when they left the hand of the fabricator.

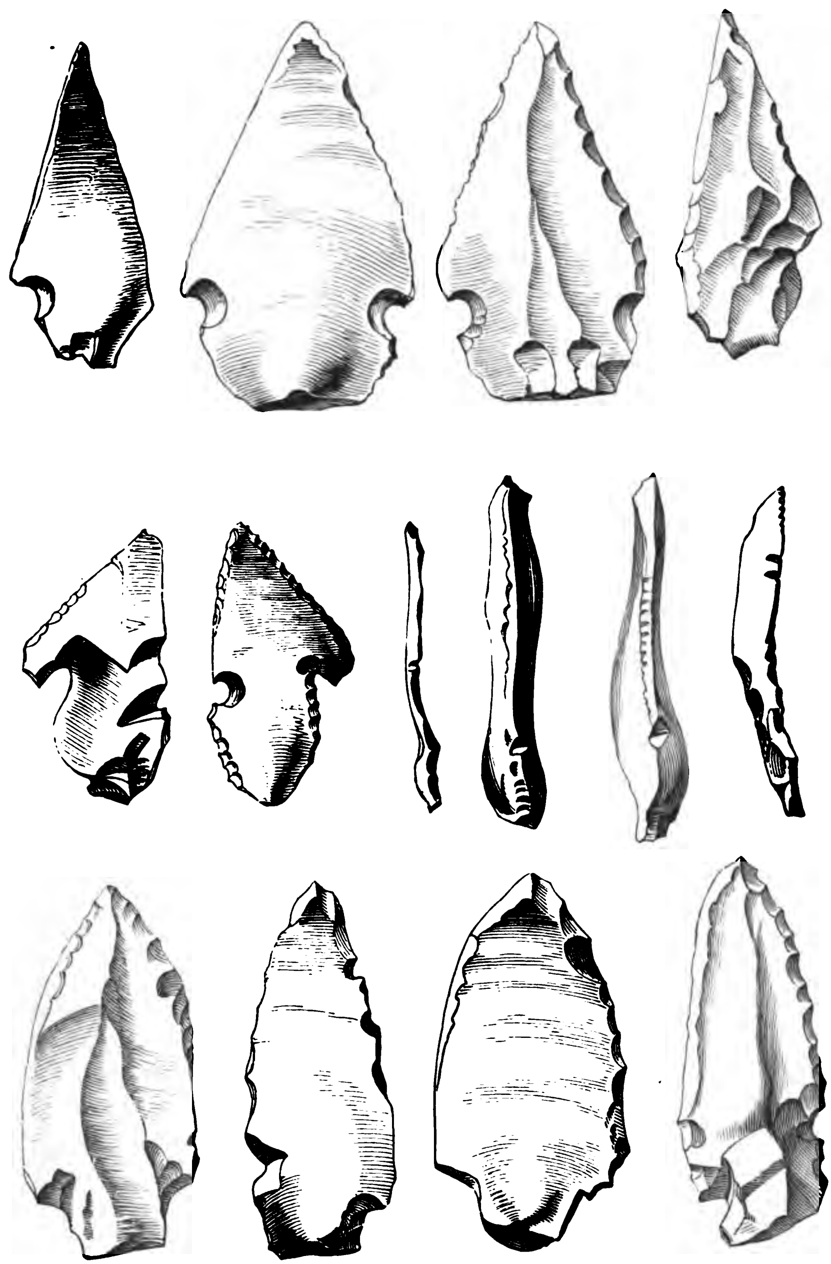
In some rare instances among the flakes from the district of Moira and Toome Bridge, in the County Antrim, these dark brown and fresh-looking flakes, when of the leaf-shaped, or rude arrow-headed form, present the first chippings near their base, or at the point, exhibiting the bulb of concussion necessary to form the wings of the perfected arrow-head; and in some rare instances similar side nicks to these are seen on the flakes from the marine drift; the chips thus given being oftentimes not as highly oxydised as the original surface and chippings along the edges of the flake.

The conclusions which my present information on this subject leads me to arrive at, with regard to the origin and the explanation of the mode of occurrence of these flint flakes, are these:—During the period of formation of our present raised sea beaches, the men of that period resorted to the out-crop of the chalk for flint nodules, from which to manufacture their mallets, hand axes, knives, rude spear and arrow-heads, and other implements, and these are the *rejecta* of that maunfacture during countless ages, the localisation of the raw material conducing to the localisation of the worked implements, lost or rejected over an area which was then covered by the sea, but which is now the land skirting the present sea coast line.

This was the first period. The second epoch finds the race of men over these areas possessed of somewhat increased mental and manual ability, who did not manufacture their flint implements merely along the coast line of the period, but carried away with them the rude flint nodules to the uplands and higher elevated plateaus, and then chipped them into finer implements, characterized by more symmetry of outline and delicacy of form than their earlier prototypes.

I believe it quite possible that the leaf-shaped flint flakes of this second epoch were known to, and seized on by the earliest of the Historic races in Ireland, to form the rough materials out of which, with great care and patience, they manufactured those delicately chipped and symmetrical winged arrow-heads, and other of the finer formed flint weapons and implements, which so often are found associated with rude pottery, beads of amber, and shells, and sometimes glass, in their sepulchral tumuli and megalithic chambers. They are not all to be regarded as refuse, for the fact of many of them being carefully chipped around their edges shows that they were regarded as perfect for the purposes to which they were applied.

The flakes given in the accompanying illustrations (Plate XIII.) are of a decided arrow-head type. These were found in the drift in the neighbourhood of Moira, county Down, and in them we have the first efforts made to convert the ruder flake into the perfected arrow-head, the bulb of concussion being at the base of the implement.



WORKED FLINT FLAKES FROM THE DRIFT NEAR MOIRA, CO. ANTRIM.

[From the Collection of the Rev. Dr. M'Ilwaine.]

Thus we see that even from the remotest period of man's appearance on earth the first effort which he made at the construction of a flint implement produced an effect on the civilisation of every succeeding race, who gradually perfected the ideas thus shadowed, as it were, to them, in the lancer of the present day wielding a weapon, the primary form of which was invented in flint by a race who lived before the present distribution of land and water on the earth.

GEO. V. DU NOYER.

To the Secretary of the Royal Geological Society of Ireland.

XXII.—ON THE GROWTH OF TURF BOGS OF FIBROUS CHARACTER. By J. S. MOORE, Esq., J. P.

[Read February 10, 1869.]

I FEAR it is not possible to discover the rate of the growth of turf or peat moss of the fibrous kind from an examination of its component parts.

There is nothing in the structure of its fibres to mark the annual growth. It increases from year to year, and from century to century, without showing any evidence of break or stop: it continues to creep up both in summer and winter, and yet the rate of vegetation must be exceedingly irregular.

In wet weather the growth will increase—in dry it will decrease. In hard frost it will cease, and the top be injured, and probably slightly decayed. In a season of long-continued drought, such as we had last summer, I have seen the surface of the bogs so dried up that a slight portion has been blown from the surface in dust. Neither the live bog, nor the turf cut from it, afford any internal evidence of its age, further than that the top turf of deep bog is generally loose, rough, light, and spongy, whilst that lying deeper becomes more dense and compressed as you go down. As I have not an opportunity of examining bog composed of sphagnum, these observations apply to the fibrous turf.

On the steep side of a mountain the rate of the vegetation of peat may not exceed an inch in a century, whilst in a swampy valley it may increase a foot during the same period. The very slow rate of the growth of the bog attracted the attention of the observant many years ago. In a practical treatise on peat moss, written by Mr. James Anderson, and published in 1794, he states: "No opinion is more generally received than that moss grows under certain circumstances very rapidly." He adds: "I can now without hesitation aver that, after thirty years' very careful attention, I have not been able to discover one instance in which I have seen a single inch of moss produced upon the surface, though I have examined many hundred of acres of these mosses that are generally called growing mosses in that country" (Scotland).

In laying before you, by way of illustration, some fibrous turf, grown under various circumstances, I may remark, that, in opening a bank of turf, the custom is to pare off the rough surface sod to a depth of about six inches. The uppermost turf will, therefore, be taken from six inches below the surface. The first turf I produce was cut from the top of a bank less by the six inches; the bank itself was five feet in depth. This turf, you will observe, is of the light and spongy character; the coarser and lighter particles appear towards the top; the turf has shrunk in drying; towards the lower end it becomes narrower and more condensed.

Looking at some of the fibrils exposed on the side of the turf of the length of about four inches, one would hesitate in pronouncing their growth to be more than that of a twelvemonth, and yet many are of opinion the growth of the bog in the most favoured locality would not exceed that of one foot in a century. If this opinion be received as approaching to correctness, one of those little four-inch fibrils may represent the growth of more than thirty years. Towards the lower end of the turf you will observe the fibrils decrease in size.

Let us now examine a bottom turf taken from the depth of five feet. This is hard, black, and heavy. The fibrils have become attenuated to the thickness of fine silk threads. They are no longer the chief component parts of the turf, but are embedded in a close dense mass of decayed vegetable matter, evidence of long years of compression, decline, and decay.

Turn now to the turf taken from the bog nine feet deep. Of the top turf I have nothing to observe other than what has been already remarked about that from the five feet bog, except to point out the gradual shrinking in both those turf from their upper to the lower part, and the greater amount of condensation which occurs in their lower parts.

The turf taken from the five feet depth shows the gradual increase of density caused by age and compression; but that taken from the nine feet depth affords evidence not only on the subject of age, weight, and density, but also of the amount of shrinkage which has taken place since these turf were cut. They are now about three inches wide, and twelve inches long. When cut they were five-and-a-half inches wide, and fourteen to fifteen inches long; they have consequently shrunk since they were cut about two-and-a-half inches each way in length and breadth. How do we arrive at this fact? The breadth of a turf spade, with the fly, is five-and-a-half inches. Such a spade will cut turf to fully that breadth, or perhaps a little more.

An additional proof arises from a small branch of birch growing across the centre of the nine feet deep turf; it measures five-and-a-half inches, and protrudes about an inch on each side of the turf, proving the shrinkage to have been about two-and-a-half inches as above stated.

The next thing I come to is weight.

	lb.	oz.
The top turf of the nine feet bog weighs, ...	1	8
That from five feet deep, ...	1	12
And that from the bottom at nine feet deep, . . .	2	5
The turf from the two feet bank weighs, as we should expect, viz.: the top one, which was of slower growth than the top of the nine feet bog, weighs,	1	11
And that from the second foot, ...	2	0

The time required for the growth of these two may have been as great as that for the nine feet bog. We find, therefore, the top turf more dense, and weighing more than the top turf of the deeper bog, as it grew more slowly. The second turf, not so heavy as that cut from nine feet deep (wanting, as it did, the weight and compression, caused by the superincumbent seven feet of bog); but it is more dense, and of greater weight than that cut from the depth of five feet. Owing to the circumstance of this two feet bank being on higher, drier, and more sloping ground than the nine feet bog (which lies in a hollow), the lower part of the two feet deep turf may be of an equal age with that taken from the nine feet, though so disproportionate in depth.

If we meet with a bog twenty feet in depth, and estimate its age at only two thousand years, on the assumption that bog grows at the rate of one foot in a century, we miscalculate sadly.

The top turf increases, say at that rate; next century produces another foot over that, and so it continues until the depth of the whole is twenty feet; but as each foot of bog after the first growth became covered over and buried beneath the newer vegetation, the under bog decayed, and became more and more condensed by the pressure from above, as the bog became deeper, until at length, what had at one time presented a foot of thickness (the growth of a century) may now be rotted away and compressed to the thickness of an inch under the weight of nineteen superincumbent feet of bog—that inch representative of one hundred years. Examine the thickness of the fibrils of the top turf, compare them with those of the bottom, and you will find them diminish, as the turf descends, from the thickness of a coarse woollen thread of several inches in length to that of a few short fragile fragments, each scarcely thicker than a human hair.

I inquired of an old turf-cutter if, when a bank is cut down to within a few inches of the bottom, and the top sod laid over it, will that top sod unite with the bog under, and will it grow again? Answer: the top sod will grow, but will not unite with that under it. How do you know that? Because we have, in cutting, come down to where, at some former period, the turf had been cut away to near the bottom; the top sod had been then laid down upon the denuded part, and had grown to five or six feet of turf before we again began to cut. We found the separation between them perfect, and pieces of old turf remaining from the former cutting. I inquired how many years had

it been since that former cutting. He replied, "God only knows; hundreds of years!!"

If the top turf grows at the rate of only one foot in a century, and if that foot in the course of time becomes buried under several other feet of turf, and that each foot becomes more and more compressed, from decay of its component parts by pressure of the constantly increasing weight and mass above, until it becomes squeezed into a thickness of two or three inches, what number of years had elapsed from the time the cache of Ballinatona was made and buried again under the growth of six feet of bog, to the day on which Mick Higgins, having cut through the six feet of turf, had fallen into the cache and once more exposed it to the light of day? Who can calculate?

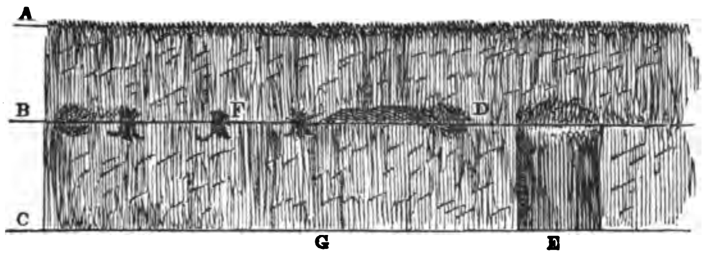
XXIII.—On the Discovery of a Cache at Ballinatona, near Blesinton. By J. S. Moore, Esq., J. P.

[Read February 10, 1869.]

Between the townland of Ballinatona, and the base of Sorrell Hill, in the Barony of Lower Talbotstown and neighbourhood of Blesinton, lies a turf bog which is in some places eleven or twelve feet deep; in other parts the bog has been either cut or worn away nearly to the gravel. Upon the denuded parts are roots of oak, of birch, and of fir, with occasionally a prostrate stem. The face of the particular bank of turf had been cut to a depth of six feet from the surface. During the last summer, a farmer was cutting his winter's stock of firing, the ground gave way under his feet, and farmer Michael Higgins dropped into a hole. On examination, the hole appeared to be circular, about four feet wide at top, and supported all round by piles. Michael cleared out the hole (which we may call a *cache*) to the depth of five feet; he then came to the gravel; unfortunately the pot of gold or other treasure had been removed, and Michael had nothing for his labour. Many were the conjectures as to the origin of this pot, which Michael likened to a sugar hogshead. The general opinion of the country people was, that a passage had been cut for some distance under the bog, the excavation made then rendered comfortable by being lined with piles. On top of this excavation lay six feet thick of bog, *solid*, and *undisturbed*. I was accompanied by my brother, Mr. George Moore, and by one of the Fellows of this Society, the Rev. Maxwell Close. We soon decided against the theory of the country people; we could not find any trace of a passage leading to the excavation. The piles appeared to have been driven down, which could not have been done conveniently under the six feet of bog. We came to the conclusion that at the time the cache was made, the surface of the bog was at the level of the top of the cache or perhaps some inches above it; that the mouth of the cache was covered over with boughs or branches of trees, and they, probably, concealed by sods and heath;

that when the cache had fulfilled its purpose, and the treasure been taken away, the sods were replaced; that the bog has since grown over to the depth of six feet. In support of this view, the tops of the

SECTION OF THE GROUND IN WHICH THE CACHE WAS DISCOVERED.



A. Level of present surface of peaty ground.
B. Level of former forest.
C. Level of granite detritus.
D. Detritus supposed to have been thrown out from bottom of Cache E.
E. Cache, 5 feet deep, 4 feet in diameter, lined all round with upright poles of birch.
F. Remains of former forest of birch, fir, &c., &c.

piles had a battered appearance, as if they had been beaten down and driven into the bog down to the gravel. We concluded that the artificer dug out the hole in the bog until he met with the gravel; that he had thrown out some of the gravel, for we found a little spread through the bog for the distance of about four or five feet from the top of the cache, and on a level with it (such being about the distance to which the operator would easily have thrown it out of the pit. The slight trace of gravel did not continue farther along the face of the bank than those few feet. The piles were of birch with the bark yet adhering to them, and on the same level as the mouth of the pit. At a few yards distance was the root of a birch tree, which had been laid bare by the turf having been cut from over and around it: probably it was from this very tree the branches, four or five inches in diameter, had been cut to form the piles. On raising and examining one of the piles, the lower end appeared to have been cut from the tree with a hatchet: the cuts were so clean, that the date of their being felled may be remitted from the age of stone to that of iron or bronze. On the same level of the root of the birch, other trees had grown as well of birch as of oak and fir. Judging from the depth of the bog under the top of the *cache*, we may estimate the depth of that under those other roots at five feet. The age of the cache cannot be determined from the depth of the overlying bog, the rate of the growth of bog being so variable. There was no appearance of any wood or timber in the overlying six feet of bog. Doubtless, other growths would be found under those roots in the five feet of bog beneath. A question then arises—why should those trees have grown upon the gravel, and at several heights above in the bog, to the extent of five feet, and not have con-

tinued to grow in the overlying six feet? Was it, that such trees could not grow on a greater depth of bog than five feet, or were they affected by a change of climate preventing their farther vegetation? No trees could grow up on that high bleak and exposed situation if now planted, and yet I have seen birch trees growing in deeper bog, but in a much lower and more sheltered position. The altitude of those roots at Ballinatona may be about 1000 feet above the level of the sea.

The Common Ordnance map does not show any trace of wood growing on this part of Ballinatona, or in the neighbourhood, and yet the geological inch map shows this place to have been on the edge of a considerable forest.

XXIV.—The Gold Fields of Scotland. By W. Lauder Lindsay, M. D., F. R. S. E., F. L. S. (Plates XIV., XV.)

[Introductory Note.*—The Author desires to explain that the following Paper owes its presentation to this Society to the fact that recent paragraphs, not only in the Edinburgh, and generally in the Scotch newspapers, but also in the "Times," relative to an alleged rediscovery of Gold in Sutherlandshire, have re-awakened public interest in a subject which never fails to excite wide-spread curiosity—viz., the existence of native gold. Every now and then, similar sensation paragraphs appear in the Scotch newspapers regarding the re-discovery of gold—sometimes in the northern, more generally in the southern, counties; and these announcements are usually followed by the wildest speculations as to the results to Scotland of the development within its area of payable Gold Fields!

The Author is led to hope that the following results of his own observations may contribute, on the one hand, towards putting the matter of native gold in Scotland in its true light; and, on the other, towards calling forth from various quarters authentic records of gold-finds in Scotland—records that may, in the aggregate, form a basis for a future thorough scientific inquiry as to the extent and circumstances of auriferous deposits in North Britain.

A much greater interest of a scientific kind has been developed in England and Ireland than in Scotland in relation to native gold (e.g., the gold workings of Merioneth and Wicklow). A Paper presented by the author to the Royal Geological Society of Ireland in January,

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* Dated December, 1868, prior to the development of the "Sutherland Gold-diggings," though subsequent to Robert Gilchrist's announcement of his discovery of gold in payable quantity at Kildonan. The present communication contains, therefore, no description of the "Sutherland Gold-diggings," or its results. This is reserved for a separate paper, when the diggings in question have come to a termination, which they have not yet done.

1865,—and published in its "Journal"—on the New Zealand Gold Fields, led to an animated discussion, in which some of the most distinguished geologists of Dublin took part (e. g. Professor Haughton, and Messrs. Baily, Sanders, and Scott); and the result of the said discussion was the elicitation of much information of great interest regarding the present working, as well as the past history, of the Wicklow Gold Mines. Readwin, Phillips, and others have done the same service at the "British Association" for the Welsh Gold Mines. And I see no reason why Scotland, in which gold is probably as extensively distributed as in either Wales or Ireland, should not discuss the subject of its auriferous deposits in a similarly scientific spirit. Such discussion is apparently the only efficient means of satisfying the public mind, and of putting an end to the vagaries of enthusiastic and sanguine inhabitants of alleged auriferous districts. Under these circumstances—impressed with such belief—the present communication is offered to the Society more as a basis for discussion than as a contribution of novel facts, or as an addition to existing knowledge.]

While visiting, in 1861, the auriferous districts of the province of Otago, New Zealand, I was much struck with the similarity, as respects physical geography and geology, between that country and many parts of Scotland. It immediately occurred to me that, in so far as the same physical conformation obtained, and the same geological structure existed, in many parts of Scotland, there might be a coequal diffusion of gold, as respects, at least, its area; and I proposed to myself to determine how far this suggestion or belief could be borne out by actual investigation. Since that period,* I have given all the attention that opportunity permitted to the subject of the diffusion of gold in Scotland, both as regards its area and quantity. I have traversed Scotland in its length and breadth, and visited its principal outlying islands (the Hebrides, Orkney, and Shetland.) In 1863 I paid a special visit to the Leadhills district, which, some centuries ago, yielded, to systematic working, upwards of half a million worth of gold, and which, regarded by the test of its then productiveness, is fairly entitled to the appellation of a "Gold-field." In order to compare the Scottish gold and gold rocks with those of other auriferous countries, I made a special examination of the International Exhibition of 1862, and of all the Museums accessible to me in Britain, Australia, and New Zealand. I have likewise studied, so far as appeared to be necessary, the somewhat voluminous literature of gold and gold rocks—of the mineralogy and geology of gold—in Scotland and other auriferous countries. In doing so, I very soon found I had been forestalled, to a certain extent, both in my anticipations or belief, and investigations, by an Australian mineral surveyor—Mr. Calvert—who had been struck in a similar way with the apparent resemblance between the gold rocks of Australia and

* Up to 1867, when these notes were drawn up.

those of Britain: who subsequently traversed and "prospected" the suspected or ascertained auriferous districts of Britain, including Scotland: and who gave a summary of his results and of his literary investigations in a work entitled "The Gold Rocks of Great Britain and Ireland," published in 1853. This work does not appear to me to have attracted that attention in Scotland which it deserved; and this may have arisen from the speculative views which pervade it. But it contains much important information, compiled from a variety of sources—historical and archæological—regarding former gold workings, and the ascertained or supposed distribution of gold, in Scotland. I shall, however, avoid in the present communication recapitulating information which is so easily accessible to those interested, and propose confining myself more particularly to my own inquiries, the results of which are confirmed by those of Calvert, so far as his go.

The remarks I have now to offer are thus based on a—

1. Personal survey of the gold fields of New Zealand.
2. Personal superficial survey of Scotland and its principal outlying islands.
3. Inspection of the specimens of gold and gold-rocks in the principal Museums of Britain, Australia, and New Zealand.
4. Study of the literature of gold in Scotland and other auriferous countries.

My special conclusions regarding the Scottish gold fields are based mainly on—

1. The similarity of certain groups of the rocks of Scotland to those of all, or most, other auriferous countries.
2. The actual discovery of gold in Scotland in former and recent times, as illustrated by prehistoric remains and historic records.

My general results or conclusions are—

1. That gold is much more extensively or generally diffused in Scotland than has been hitherto generally supposed.
2. That the area of diffusion, and the extent to which it now occurs, can only be determined by systematic investigation, equivalent, at least, to the "prospecting" of gold diggers.
3. That hitherto, with certain limited and local exceptions, there has been no such recent systematic "prospecting" in Scotland.
4. That there are indications—if they do not always amount to proofs—of the existence in Scotland both of auriferous quartzites (that is, of gold *in situ*), and of auriferous "drifts," using the term "drift" in its most comprehensive sense.

Let me here at once disabuse the minds of my audience or readers of any sanguine expectation that I am as yet prepared to announce the discovery of a "payable gold field" in Scotland, or to recommend, as a profitable speculation, the establishment of a company to operate on either its quartzites or drifts. I will have occasion to show, in the course of my remarks, that in certain senses—(but only in these senses)—gold-washing or working in Scotland actually is, and might still further become, remunerative—that it does and might further take a place as one of the

local "industries" of our country.* But my object is at present the much humbler one of simply endeavouring to draw attention to a subject which pre-eminently requires local investigation over a wide area —investigation of a kind, however, so simple that it may appropriately be undertaken by the parochial clergy or medical practitioners, as well as by resident proprietors or their representatives. More especially do I deem the subject one befitting the attention of our National Surveys, geological and topographical. The former has recently been revivified in Scotland by the appointment of a most complete and active Director, and by a considerable increase of its working staff. Save in Peebleshire, the Geological Survey has scarcely yet (so far as I am aware) entered on an examination of the Lower Silurian districts, which may be expected to be more or less auriferous throughout Scotland. Hence, I think that "prospecting" for gold, which does not involve the necessity for costly instruments, or much expenditure of time, might be made a legitimate and proper department of the duties of the working staff of the Survey in question. I have no doubt that investigations so conducted would add largely to our knowledge of the area over which, and the extent to which, gold is distributed in Scotland, while they would rectify many errors that at present exist.

Before making general observations on the Scottish gold fields, or comparing them, as regards their richness or extent, with those of other auriferous countries, which are better known, I propose giving briefly the principal results of my observations and inquiries at and concerning what I may safely denominate the Crawford or Leadhills "Gold-field." The whole of that moorland and hill region, (much of it bleak and sterile, or suitable only for sheep pasture) of the southern Highlands—in upper Clydesdale, the southern extremity of Lanarkshire—variously known as Crawford, Crawford-Moor, or Crawford-Lindsay (once one of the many and valuable possessions of the powerful house of Lindsay)—which includes the district now known as the Leadhills, and forms the watershed of the four great southern rivers—the Clyde, Nith, Tweed, and Annan—has repeatedly and in various ways proved to be auriferous. Calvert "prospected" the whole Leadhills district, and found gold in every gully and valley. Griffin also prospected this region with the similar result, that he found gold in dust or grains "everywhere." But long prior to their modern system of "prospecting," some of the Lead-

* The correctness of this opinion or assertion has been amply proved by the history of the *Sutherland Gold-diggings* which have already supported a population of about 200 or 300 miners and their followers for upwards of six months, and this notwithstanding the existence of numerous and serious obstacles to successful mining. The character of these obstacles, in relation to the results attained and attainable in Sutherland, is described in a paper by the author on "The Sutherland Gold-diggings as a Scientific and Social Experiment," prepared for the "British Association" meeting of 1869 (at Exeter); and was also referred to in an article entitled "More Gold-fields in Scotland" in the "Northern Ensign" (Wick, Caithness) of June 17, 1869.

hill valleys (evidence is far from uniform as to their exact site, if it was limited) were the scene of the so-called far-famed "alluvial washings" under Sir Bevis Bulmer in 1578-92; and it was from the produce of these washings that the Scottish Regalia were fashioned in 1542, and King James IV. and V.'s celebrated "Bonnet Pieces" coined. Bulmer's chief washings are said to have been in the valley of the Elvau, a name which singularly enough signifies the "shotty water;"* and he is also represented as having washed the whole banks of the Glengonner water. Vestiges of ancient "diggings," precisely similar to those of Otago, are to be met with in many parts of the Leadhill district. For instance, I found the "haugh" or "flat," on the banks of the Glengonner water, above Abington, and immediately below Glencaple Burn, covered with a series of old grave-like mounds—exactly resembling those with which I was familiar in the famous Gabriel's gully at Tuapeka, Otago—which are said really to mark the site, or one of the sites, of Bulmer's celebrated workings. It was, it is said, the gold-prospecting of this El Dorado of Scotland in the 16th century that led to the discovery of the *Lead*, which has proved so much more permanent a source of prosperity to the district, to which it has, moreover, given its distinctive modern name. Of late years, and at present, gold is systematically collected by the Leadhill miners chiefly in certain localities, e.q., in the Windgate, or Windygate burn, in Langcleuch burn, in Bellgall burn, and in the whole course of the Elvau and Glengonner, from the Clyde to their source. The gold occurs chiefly in the gravelly clay, locally known as "Till," as this coats the flanks of all the Leadhill valleys; but it is also to be found in the shingle, gravels, or clays, of the stream-beds. Several of the miners have considerable reputation as skilful and successful gold-finders, and their practised eyes are constantly detecting gold in both localities, the hill sides and the stream-beds. This gold is invariably what is known as "drift," or "alluvial" gold. There is no present local evidence of the existence of auriferous "quartzites." But in 1803 the late Prof. Traill, of Edinburgh, found gold in a vein of quartz *in situ* at Wanlockhead.† All the gold belonging to this district, which I have seen, is of a granular or "nuggety" character, and quite comparable with the usual produce of Otago or other auriferous countries. Some of the "nuggets" found in former times, and preserved in the cabinets of local proprietors, are of very considerable size and value. The cabinet of the late Lord Hopetoun contains two, one of them weighing 2lbs. 3 oz. = 27 oz., or 12,960 grains, which, at the current price of gold in Australia (£4 per oz.), is worth £108—collected, it is said, about 1502, prior to the systematic

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* The name refers more probably or appropriately (if it refer to the prevalent local minerals at all) to nuggets of *lead* rather than of *gold*.

† In the Museum of Science and Art, Edinburgh, there are two small nuggets labelled "Native Gold in Quartz; Leadhills, 1837 (Traill)." Here the quartz is still adherent just as it is in nuggets from the Waipori diggings of Otago, N. Z.

workings of Bulmer; the other weighing 1 oz. 10 dwts., or 720 grs. The first would appear to be by far the largest mass of native gold ever found in Scotland. Since, however, systematic gold-washing on the large scale was discontinued, the size of the Leadhills nuggets has been much smaller, the largest seldom now exceeding 2 or 3 grs., though they are frequently found of that size. Just previous to my visit in the autumn of 1863, a nugget of 30 grs. had been found, and another single nugget, whose weight I failed to ascertain, sold for 25*s.* at Abington. More generally the gold occurs here as rough granules, coarser and larger than those constituting what could properly be called "dust," and of this, considerable quantities are frequently collected in limited periods for special purposes, such as marriage gifts or jewellery, or for the local proprietors. Thus, in a fortnight in 1862, 975 grains were collected for the Countess of Hopetoun; and on another occasion, 600 grs. in six weeks by 30 men, at spare hours, 15 working in the forenoon, and the other half in the afternoon. About Abington, in 1858, similar quantities were collected under similar circumstances, to furnish marriage jewellery for Lady Colebrooke. Between May and October, 1863, three miners, in the intervals of leisure from their usual work, collected for me 33 grs., which they found in the "Till," about 40 yards above the bed of the stream, half way down the Langcleuch burn, between Leadhills and Elvan-foot. Their charge was 20*s.*, that is at the rate of about £15 per oz., or 7½*d.* per grain. During the last five years the price of crude gold in Australia and New Zealand has averaged £3 17*s.* 6*d.* to £4 per oz.; so that the Scottish diggers obtained for their produce nearly four times as much as the New Zealand or Australian diggers get for theirs! The price appears at first sight to be extremely and disproportionately high.* But the cases are by no means parallel, for in the case of the Leadhills gold, the collection is made to meet demand for cabinet specimens or for jewellery material, under circumstances quite exceptional. The Leadhill miners collect their gold mostly to order; it is thus at once disposed of; and hence gold is seldom to be found at Leadhills for sale, or only in very small quantity. On one occasion I was offered a sample of 140 to 160 grs. for £5, that is, at the rate at which I purchased my smaller sample. But the miners rarely have so much in their possession unsold. In the summer of 1862, by way of holiday work, the miners frequently collected quantities of 14 to 54 grs. The able-bodied lead miner never, however, gives up his usual labour, at which he earns 15*s.* per week, for the more precarious gains to be derived from gold finding. To gold-seeking he devotes only his spare hours, his holiday time, or his periods of sick-

* A similar belief in the auriferous resources of Sutherland has led many experienced gold miners from California and other auriferous countries to express their readiness to invest both capital and labour in developing these resources, provided proper facilities are afforded to establish claims in "likely" localities.

ness or debility. The price he, generally more or less readily, obtains for his gold varies necessarily with the demand and supply. Sometimes it rises to 7½*d.* per grain, or £15 per ounce ; sometimes it falls to 5*d.*, but the more common or average price is 6*d.* per grain, or £12 per oz.: while the average *market price* of gold may be quoted at present at £4 per oz., or 2*d.* per grain. The Director of the mines at Leadhills estimates gold-washing at these prices as only capable of yielding, at present (autumn of 1863), wages of 3*d.* per day, while lead-mining gives upward of 2*s.*, or more than eight times as much, with the great additional advantage of being a constant or *regular* occupation. He, however, has such an opinion of the abundance of the gold, the facility with which it may be collected, and the probable remunerativeness of the gold-working, that, with a favourable lease of the ground, he and many others would at once combine to commence systematic operations.* Other local authorities are, however, much less sanguine of profitable results from washing the gold on whatever scale, or by whatever means, though there is a unanimity of opinion as to the general prevalence of gold and its easy accessibility throughout the district. The method of collecting gold by washing at Leadhills is essentially that employed in the early history of gold diggings in all auriferous countries. But there can be no doubt that collection would be facilitated, the produce increased, and the remunerativeness of the operation improved, by the application of the most modern machinery, now used in countries where gold mining has long become a settled industry. Even the present apparatus for washing lead might be applied, with modification, to the washing of gold—a circumstance worthy of attention in connexion with the fact that gold is found occasionally in the refuse of the lead washings.

The Scottish Gold-fields may be divided geographically or topographically into three—the Northern, Central, and Southern (Pl. XIV.)

1. The *Northern* Gold-field comprises the greater part of the counties of Sutherland,† Ross, Inverness, and Argyle (north of the Caledonian Canal.) It occupies the longitudinal axis of the northern peninsula of Scotland, is second in size only to the central area, and has yet almost entirely to be explored scientifically.‡

2. The *Central* lies between the Caledonian Canal and the valley of the Tay, and includes a great part of the shires of Inverness, Argyle (and south of the Caladonian Canal), Aberdeen, Banff, Kincardine, Perth,§ Forfar, Stirling, and Dumbarton. It is by far the largest of the

* In the summer of 1862, two miners at odd hours collected in Windgate Burn, by permission of the proprietor, £30 to £40 worth of gold.

† The experience of Kildonan and Inisgill gold-fields from January to July, 1869, has sufficiently established the auriferous character of *Sutherlandshire.*

‡ Notwithstanding the recent discoveries in Sutherland, I am of opinion that the *Southern* Gold-field, e. g., the glens forming the channels of the headwaters of the Clyde, Tweed, Nith, and Annan, are more likely to prove really auriferous than the Northern or Central Gold-fields of Scotland.

§ A couple of long articles on "Perthshire as a Gold-field," appeared in the "Perthshire Advertiser" of January 28 and February 4, 1869.

MAP SHOWING THE APPROXIMATE AREA OF THE LOWER SILURIAN GOLD FIELDS OF SCOTLAND.

The black portions represent the Great Northern and Southern Gold Field.
The horizontal tints, the additional area of the Laurentian and Cambrian Rocks.
Spots with diagonal tint, localities of real or alleged Gold Fields.

Lower Portion of the Leadhills Gold Field, Scotland—looking down Glengonner from below Waterhead.

Tuapeka Gold Field, Otago, New Zealand. South end of Gabriel's Gully—looking South.

three areas; like the southern gold-field, it forms a transverse belt across Scotland: much of it remains to be explored.

3. The *Southern* comprises great part of Dumfries, Kirkcudbright, Wigton, Ayr, Selkirk, Peebles, and Lanark-shires, and includes more particularly parts of the districts of Nithsdale, Annandale, Eskdale, Ettrickdale, Tweeddale, and Clydesdale, with Carrick, and the Lammermuirs (in Haddington and Berwick). It is the smallest of the three areas, but is the best known, and so far as yet ascertained, the richest.

Geologically, the area of these three great Gold-fields is that occupied in Scotland by the *Lower Silurian* strata and their drifts. These strata are divisible petrologically, however, only into two great groups, viz., the *Southern*, corresponding to the Southern Gold-fields, as above described, characterized by the Greywackés of the Lowthers; and the *Northern*, comprising what I have above described as the Northern and Central Gold-fields, characterized by the micaceous schists of the Grampians. But though the Lower Silurian slates are the rocks in, or in connexion with, which gold is most frequently found in other auriferous countries, and is most likely to be found throughout Scotland, experience shows that gold may be contained in a great variety of other rocks and their drifts, of other ages, both older and more recent. It is indeed much easier to catalogue the rocks or deposits in which gold does not occur, than to enumerate those in which it has been found, in different parts of the world. For instance, the recently discovered gold-fields of Upper and Lower Canada (province of Ontario and county of Simcoe in Upper, and the Chaudière valley in Lower, Canada), as well as of Nova Scotia, are, according to Dr. Sterry Hunt of the Canadian Geological Survey, in the *Laurentian* area (chloritic gneiss), while gold occurs also in Laurentian gneiss in Sweden. In Scotland the area occupied by *Laurentian* gneiss comprises the Hebrides and the western seaboard of Sutherland and Ross-shires. There is thus good ground for a careful examination of this area, though I have met with no evidence that even a trace of gold has hitherto been found within it. Again it has been stated that, in certain other parts of Canada, the gold rocks are *Upper Silurian;* so that there is no reason *à priori* why (e.g.) our Pentlands should not prove to be an auriferous area. According to Professor Whitney, certain, at least, of the gold-bearing rocks of California are yet more recent; while the experience of New Zealand, Australia, and other auriferous countries has demonstrated the frequent occurrence of gold in Granites, Syenites, Sandstones, and Limestones, and their *debris*, apparently of very different ages. Under these circumstances, it would hardly be safe to foretell or assert that gold will not be found in any given district or rock in Scotland; and there is apparent evidence to show that gold-finds have actually been made where, geologically, gold certainly was not expected, and its occurrence would not have been, by scientific authorities, predicted. All records of gold finds, however, in areas occupied by rocks not generally auriferous, require to be carefully examined. In some of these cases (e.g.) it is possible that the auriferous rocks did not belong to the district, but were erratics originally from Silurian regions;

and in other cases it has been proved that the substance supposed to be gold was in reality *Iron pyrites* or *Mica!* Thus a local newspaper of 1865 states that in *Elginshire*, a Devonian district, a gentleman picked up a piece of auriferous quartz near Woodside. Calvert states that David I. made a grant of a gold-mine in *Fifeshire*, a district which is wholly old red sandstone, or carboniferous; and gold is also recorded to have been found in other unlikely counties or localities (e.g.) *Linlithgow*, which is wholly carboniferous, and *Orkney*, which is mainly old red sandstone. Within my own recollection, about the period, I think, of the discovery of the wonderful auriferous riches of Australia, the neighbouring county of *Fife* was the scene of a regular "stampede," or "rush" to the West Lomond-hill in search of gold.* This hill consists of carboniferous shales, with intrusive beds of greenstone, overlying the upper old red sandstone (Geikie), and separating the old red sandstone of Perthshire to the north from the carboniferous system of Fifeshire to the South. Under these circumstances, it need scarcely perhaps be added that the fruit of the "diggings" of the peasantry of Abernethy and Newburgh was *Iron pyrites!* The inhabitants of the ancient "kingdom" do not seem *then* to have realized or appreciated the truthfulness of that very trite saying—"All is not gold that glitters!"†

At many localities throughout the area, which I have assigned to the Scottish Gold-fields, actual finds of gold have been made in recent or former times; and this is one of the strongest arguments for its thorough exploration. Of such gold finds, the following will suffice as illustrations:—

I.—Northern Gold-field:—

1. *Sutherlandshire*:‡ Kildonan, on Helmsdale water. A nugget found here in former times weighed 10 dwts. or 240 grs.§

II.—Central Gold-field:—

1. *Perthshire*: *A. Breadalbane*: area of Loch Tay, and head waters of the Tay. A nugget found in former times weighed 7 oz. or 960

* *Vide* the author's history of "The Fifeshire Gold-diggings of 1852 and their Lessons," read before the Geological Society of Edinburgh, March 4, 1869, of which an abstract appeared in the "Daily News" of March 15, 1869, and other contemporary Scottish newspapers.

The price of *Sutherland* gold was at first £4, but it gradually fell to £3 10*s*. per oz.

† An article on this text, and with this heading, pointing out the minerals and metals that are found in nature and art as substitutes for, or counterfeits of, gold, appeared in the "Northern Ensign" of July 1, 1869.

‡ "Sutherland as a Gold-field," was described in a series of articles in the "Northern Ensign" for February 25, March 4, June 17, and July 1, 1869.

§ Kildonan was the locality of Gilchrist's re-discovery of November, 1868, and is still (July, 1869) the chief seat of the so-called Sutherland Gold-diggings. A much larger nugget has recently been found in Luisgill—viz., that known as the "Rutherford Nugget," which weighed 2 oz. 19 grains, and was bought for £9. The author presented a "Preliminary Report on the Sutherlandshire Gold" to the Geological Society of Edinburgh in March 4, 1869, whereof an abstract was published in the "Daily Review" of March 15, and other contemporary Scottish newspapers.

grains. Sir James Simpson tells me he was shown a specimen of gold with its matrix (quartz) by the late Marquis of Breadalbane, from Tyndrum, where argentiferous galena occurs in Mica slate near its junction with quartz rock (Nicol); a circumstance parallel to the occurrence of lead in the graywacké of Leadhills. In 1861 Prof. Tennant, of London, found gold in quartz, associated with iron pyrites, at Taymouth.

B. *Upper Strathearn:* area of Loch Earn, and the head waters of the Earn, Loch Earn Head (Murchison): Glen Lednock (Ritchie): streams falling from the north into Loch Earn (Ritchie): Ardvoirtich, south side of Loch Earn, in mining for argentiferous galena (Ritchie): Glenturret (Ansted).

C. Glenalmond (Mercer): Glenquoich, and other valleys of the Grampians (Nicol).

2. *Forfarshire:* Clova district: "Braes of Angus," Edzell and Glenesk (Archives of the House of Lindsay).
3. *Aberdeenshire:* area of the Dee: Braemar: Invercauld (Bruce); coast about Aberdeen, in the sea sand (Leask). In New Zealand, and other auriferous countries, gold is very commonly associated with *Magnetic Iron-sand,* containing or not *Titanium* and other minerals, or with Iron-sulphides. It is of interest to know that the sands of the Dee, which consist mainly of the *debris* of granite and gneiss, contain considerable quantities of Magnetic Iron-sand and Iserine, with which are associated smaller amounts of Titanium, Uranium, and Arsenic (late Prof. Thomson, of Glasgow). The gneiss of Braemar often contains much Magnetite in place of mica (Nicol); while Iron, as oxide or sulphide, is common in all the schists and granites of Aberdeenshire (Nicol).
4. *Argyleshire;* Dunoon.

III.—SOUTHERN GOLD-FIELD:—

1. Head waters of the *Clyde,* including the rich Crawford moor or Leadhills district: Elvan water: Glengonner: Glencaple: Bellgall Burn and Midgate Burn: Mennlock and Wenlock:* Shortcleuch and Langcleuch: Lamington Burn: Cumberhead: Lanarkshire (Ansted).
2. Headwaters of the *Tweed:* Mannor water, which flows north to the Tweed: Meggat water, which flows south to St. Mary's Loch: Douglas water: other feeders of the Yarrow; Glengaber.† There are traces of prospecting and digging in former days in Meggat water valley, similar to those which occur at Leadhills. In the British Museum I saw two specimens of Tweeddale gold—the one a nugget in quartz, a very rich sample; the other granu-

* The largest nugget found at Warlockhead weighed 4 or 5 oz., and is now in the British Museum [Bremner "Industries of Scotland," 1869].

† A nugget weighing 30 oz. is stated to have been found by the early miners apparently in Glengaber, a tributary of the Maggat water (Bremner, p. 116).

lar rather than nuggety. Griffin prospected St. Mary's Loch district, and found gold in dust or granules everywhere.

3. Head waters of the *Annan:* Moffätdale, streams falling into Moffat water: Hartfell range above Dobb's Linn. Several small finds of gold were made in the summer of 1863; and one small nugget weighing about 6 grs. was then exhibited in Moffat.—("Scotsman," Aug. 10, 1863.)

It ought to stimulate to the search for gold in Scotland that gold mining companies are in actual operation in Ireland (Wicklow) and Wales (Merionethshire). In the former the works appear to be what are generally known as "alluvial," or washings, while in the latter the operations are more properly those of quartz-reefing or mining. Hitherto there have been few well authenticated discoveries of gold *quartzites* of any extent *in situ* in Scotland, but this is simply, I believe, because they have not been systematically looked for. That they occur is rendered at least probable by the fact of the frequent discovery of nuggets with the matrix adherent; while, in all old historical references to the working of gold in Scotland, gold *mines* are spoken of, a phrase which, though an ambiguous and comprehensive one, leaves open the question whether quartz reefs and reef-crushing were not known in and about Bulmer's time. The auriferous quartz reefs of the Clogau mountain, near Dolgelly, Merionethshire, penetrate strata of Lower Silurian age, resting on the Cambrian series, and disturbed here and there by eruptive greenstone. The gold is there associated with metallic Sulphides (iron, copper, lead, and zinc); metallic Oxides (iron and copper); Telluric bismuth, graphic tellurium, ores of silver, and other minerals. In Wales, moreover, gold occurs, as it does in New Zealand and other auriferous countries, in the clay or loam which covers the tops as well as flanks of hills. Irish geologists, again, have recognized a close resemblance between the features of the Tuapeka gold-field of Otago, New Zealand, and that of Croghan Kinsella, in the county of Wicklow. In a most interesting discussion on a paper descriptive of the Otago gold-fields, which I laid before the Royal Geological Society of Ireland in January, 1865, a mass of gold worth £120 was exhibited fresh from the Carysfort Mining Company's Works, Wicklow, while its exhibitor remarked, "He might adopt the geological description contained in the paper just read as applicable to the gold-fields of the county of Wicklow. The parallel between the two districts was so complete that he could almost fancy the gentleman who described the New Zealand gold-fields had never stirred beyond the valley of Croghan Kinsella."

It were premature perhaps to discuss the remunerativeness of gold-working as a national industry, or even the question whether it is destined ever to become again, as it once was, at all events, a local industry, until we are in possession of data showing approximatively the extent and richness of the Scottish gold-fields. Our present data are of the most imperfect and unsatisfactory kind, and yet they are sufficient, I think, to demonstrate the fact that gold is widely distributed over Scot-

land, and to render it of at least scientific importance to make the exact area and richness of its distribution a subject of systematic research. Meanwhile, the evidence collected goes to show that gold-working is not remunerative in Scotland to skilled and able-bodied labour at the current high rates of wages, while it may be made remunerative as a field of extra work to paupers, gipsies, or other persons, the value of whose labour does not exceed 3*d*. per day.* The gipsies of Hungary, men of roving life and idle habits, wash gold in the Transylvanian rivers when it is too hot in summer for other avocations. They thus gain a livelihood which, precarious and speculative though it be, is yet suited to their nomadic tastes and habits. They wash the finer sands on a wooden tray covered with woollen cloth, and the coarser gravels on a ribbed board (Ansted); a procedure which *mutatis mutandis* is what is adopted by gold-diggers in alluvial washings in New Zealand, Australia, California, and all other auriferous countries.†

I had intended instituting comparisons between the Scottish gold-fields and those of Otago, New Zealand, and also of making certain observations on the "Auriferous Drift" of Scotland; but my present remarks have so far exceeded the limits I originally proposed to myself, that it is desirable to treat each of these remaining subjects in a separate paper on some future occasion.

Since visiting the New Zealand gold-fields in 1861, I have made notanda of all instances of gold-finds or gold-workings in Scotland, records of which I have found in the course of miscellaneous reading or correspondence. These notanda include—

I. Newspaper paragraphs.
II. Quotations from (*a*) topographical works.
(*b*) historical, or
(*c*) archæological.
III. Extracts from title deeds of landed proprietors in auriferous districts, contained for the most part in the Archives of the old ruling families of Scotland, especially the Lindsays.‡

These paragraphs, quotations, or extracts refer to—

I. Recent finds of gold in Sutherland,§ Peebles, Dumfries, Lanark, or other counties.

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* The Sutherland gold-field, though developed only to the most limited extent, has already shown itself capable of remunerating not only poor and unskilled peasants and fishermen, but experienced and well-to-do miners from California, Australia, and New Zealand.

† These or similar appliances may at the present date (July, 1869) be seen in operation at Kildonan or Luisgill in Sutherland.

‡ *Vide* (e. g.) Jervise's "History and Traditions of the Land of the Lindsays in Angus and Mearus," 1853, pp. 82, 83.

§ Including materials for a full history of the Gold-diggings at Kildonan and Luisgill.

II. Descriptions of gold mines or workings of bygone ages, e.g., in Lanarkshire and Forfarshire.

III. Reservations of supposed or alleged auriferous lands, in old Title-deeds.

IV. Descriptions of golden ornaments of prehistoric age, *presumably* the results of native material and workmanship.

Should the present subject sufficiently awaken interest in the Society to justify a supplementary paper, I will be glad to throw the notanda in question together for presentation at some future meeting.

XXV.—Notes on Some Irish Crania from the County Tipperary. By Alexander Macalister, M. D., Hon. Sec.

[Read May 12, 1869.]

The Anatomical Museum of Trinity College has recently been enriched by the addition of a collection of typical Irish skulls; and these, as fair specimens of the Crania of the existing Irish race, are of considerable ethnological interest. Although many of them are in a very imperfect state of preservation, yet I have succeeded in obtaining measurements of all but one, which is in so fragmentary a condition that no useful measurements could be procured. With the Crania there are a large number of separate lower jaws; but, unfortunately, we cannot—except by guesswork—assign these to their proper Crania, and so I have preferred numbering and describing them separately. This is the more to be regretted, as I believe the lower jaw is a portion of the Cranium whose value to the ethnologist has not been sufficiently recognized. The numbers affixed to the specimens are those by which they are distinguished in the Museum, and the measurements are in decimals of the English inch.

From a survey of the measurements in the subjoined Table, it will be found that the entire group, with a single exception, are true dolichocephalic Crania. The exceptional instance, No. 16, belongs to the eurycephalic* group of Professor Huxley. Seven of the series belong to the mecocephalic subclass, and six are orthocephalic.

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* The classification of the Crania adopted here is that very useful one suggested by Professor Huxley, depending on the cranial or cephalic index (the proportion subsisting between the greatest breadth and the length, the latter being taken as 1·00), All Crania having a cephalic index of 0·80, or over, are brachycephalic; all below this are dolichocephalic. The former group is subdivided into two—those with the cephalic index above 0·85 = brachistocephali, those between 0·85 and 0·80 = eurycephali. Of the dolichocephali, those between 0·80 and 0·77 are sub-brachycephali; those between 0·77 and 0·74 are orthocephali; those between 0·74 and 0·71 are mecocephali; while all those whose cephalic index is below 0·71 are mecistocephalic.

No.	Circumference above Naso-frontal Suture.	Fronto-Occipital Arch.	Including Frontal Portion.	Parietal.	Occipital.	Inter-mastoid Arc.	Longitudinal Diameter.
1	22·00	15·90	5·75	5·15	5·00	14·50	7·40
2	20·25	13·98	4·62	4·86	4·50	13·25	7·00
3	20·65	14·00	5·00	4·80	4·20	15·00	6·90
4	20·50	14·76	4·90	5·36	4·50	14·20	7·00
5	20·37	14·05	4·65	4·90	4·50	13·60	7·10
6	20·20	14·70	4·90	5·50	4·30	14·00	6 85
7	21·20	15·55	5·50	5·10	4·95	14·20	7 30
8	20·20	13 75	5·10	4·15	4·50	14·00	7·10
9	20·65	15·00	5·00	5·52	4·51	14·90	7·20
10	20·40	14·90	5·00	5·30	4·60	14·20	7·20
11	20·25	"	4·60	4·60	"	"	6·90
12	20·72	14·80	5·00	5 50	4·30	14·20	7·20
13	"	"	"	"	"	"	"
14	"	"	4·90	5·00	"	"	"
15	20·40	14·70	5·20	4·50	5·00	14·30	7·28
16	20·60	14·65	5·20	4·80	4·65	14·20	6·95
17	21·00	15·25	5·12	5·12	5 10	14·40	7·18
Average, . .	**20·50**	**14·70**	**5·01**	**5·01**	**4·60**	**14·20**	**7·10**
Average, 10 Irish Male (Davis),*	21·30	15·10	5·10	5·40	4·70	14·80	7·50
16 ditto, . .	21·20	15·10	5·10	5·20	4·80	14·80	7·50
Average, 15 Irish Female (Davis),*	20·10	14·50	5·00	4·90	4·50	14·20	7·10
Average, 31 Irish M. & F. (Davis),*	20·60	14·80	5·00	5·00	4·60	14·50	7·30
Averages of 39 Davis and 16 T. C. D. Specimens.	**20·55**	**14·75**	**5·00**	**5·00**	**4·60**	**14·35**	**7·20**

* The numbers marked with an asterisk are those of the skulls in the celebrated Barnard Davis collection; they are the average of 26 males and 15 females measured by Dr. Davis, and recorded in his "The-

No.	Transverse Diameter.			Height.	Cephalic Index.	Length of Foramen Magnum.	Interzygometric Width.	Height of Face.
	Frontal Breadth.	Parietal.	Occipital.					
1	4·95	5·67	4·35	5·37	0·766	1·37	„	2·92
2	4·70	5·30	4·30	5·10	0·757	„	„	2·00
3	5·13	5·10	4·60	5·90	0·739	„	4·8	2·90
4	5·10	5·20	4·20	4·90	0·742	1 60	4·6	2·80
5	4·80	5·10	4·40	5·50	0·718	1·40	5·1	2·63
6	4·70	5·30	4·20	5·90	0·772	1·52	5·1	2·70
7	4·70	5·60	4·30	5·20	0·767	1·50	„	„
8	4·85	5·35	4·30	5·70	0·674	1·50	„	„
9	4·60	5·40	4·20	5·90	0·750	1·50	4·9	„
10	4·70	5·30	4·30	5·10	0·736	1·50	„	2·80
11	4·35	5·10	4·40	„	0·739	„	„	„
12	4·60	5·30	„	5·40	„	1·60	„	„
13	„	„	„	„	„	„	„	„
14	4·80	5·20	„	„		„	„	„
15	4·60	5·25	„	„	0·721	„	„	„
16	4·55	5·80	4·70	5·60	0·834	1·25	5·3	2 60
17	4·70	5·50	4·50	5 80	0·764	1·50	5·1	2·50
Average, . .	**4·70**	**5·30**	**4·30**	**5·40**	**0·754**	**1·47**	**4·98**	**2·73**
Average, 10 Irish Male (Davis),*	4·80	5·10	4·50	5·30	0·760			
16 ditto, . .	4·70	5·10	4·40	5·20	0·750			
Average, 15 Irish Female (Davis),*	4·60	4·80	4·20	5·20	0·760			
Average, 31 Irish M. & F. (Davis),*	4·60	4·90	4·30	5·20	0·740			
Averages of 39 Davis, and 16 T. C. D. Specimens,	**4·65**	**5·10**	**4·30**	**5·30**	**0·747**			

saurus Craniorum," p. 70. The last average is that of the sixteen measurable crania of the present collection, taken with the thirty-nine described by Dr. Davis, being thus an average drawn from fifty-five skulls.

As some of these skulls display anatomical points of interest, I have appended to the measurements the following notes:—

1. Broadly ovate in *norma verticalis;* exhibits inconsiderable degree of alveolar prognathism in *norma lateralis*, cryptozygous; in *norma verticalis* exhibits a trace of the sutura infra-orbitalis transversa described by the late Professor H. Halbertsma, and a deep vascular groove in the nasal process of the superior maxilla (Luschka, in Virchow's "Archiv"). The palate is deep and narrow—sutures open. This is the largest of the group, and belonged to a powerful adult male. The foramen magnum is placed 2·25 from the occipital protuberance, and 4·25 from the nasal process of the frontal bone. The spheno-parietal sutures measure 75 long, and have no Wormian or intercalary bones in their track. There is one parietal foramen; and the axes of the glenoid cavities, if produced inwards, meet at a point two lines behind the anterior lips of the foramen magnum. A line drawn from the posterior lips of the external auditory meatus passes through this point. Nasal bones large; a small trace of a frontal suture is visible for one inch above the fronto-nasal suture.

2. An imperfect calvarium, with large parietal eminences, and a depression between them in the median line. This is the lowest of the groups in inter-mastoid arc—a male skull, with open sutures; axes of glenoid cavities meet at the anterior lip of foramen magnum, in front of which lies the interauricular line.

3. An oblong cryptozygous head in norma verticalis; slight tendency to maxillary prognathism; frontal sinuses large; the anterior margin of the parietal a little depressed, exhibiting a slight tendency to klinocephalus (Virchow), but with no premature closure of the spheno-parietal suture. Nasal bones very large. A rudimental third pterygoid plate on the sphenoid. Anterior lips of foramen magnum depressed, giving to that opening a downward and backward direction. Occipital crest and protuberance large. Mastoid processes unusually developed, being 1·1 in length. Spheno-parietal suture small; axes of glenoid cavities meeting, if produced inwards, at a point two lines behind the anterior lips of foramen magnum. A line drawn from the posterior margin of the outer auditory meatus passes ·4 from the anterior lip of the foramen magnum, which is 2 in. from the occipital protuberance, and 4·5 from the nasal spine of the frontal bone: this is also an adult male skull.

4. A female, with strongly marked alveolar and slight maxillary prognathism in norma lateralis; the skull is cryptozygous, and elliptic in norma verticalis. The frontal suture persists, and all the other sutures are open, except the posterior two-thirds of the sagittal, and the upper angle of the lambdoid. Frontal sinuses small; occipital protuberance large; mastoid processes moderate, larger than in most females; pterygoid fossa deep, and hamular process long. Nasal spine of superior maxilla very long and prominent; nasal process of same bone with a deep vascular groove. Spheno-parietal suture short, only ·35 long. Foramen magnum placed 1·6 from occipital protuberance, and 4·1 from

the nasal spine of the frontal. Axes of glenoid cavity point towards a spot corresponding to the anterior lip of the foramen magnum; line from the posterior lip of the external auditory meatus cuts off the anterior ·2 of foramen magnum. The maxillo-palatine suture is straight. A second sphenoidal spine projects in front of the spinous foramen.

5. A very dolichocephalic male Cranium, phænozygous (Busk) in its norma verticalis, showing decided alveolar and maxillary prognathism in norma lateralis; has a prominent occipital protuberance; the spheno-parietal suture is only ·25 of an inch long; the foramen magnum is placed 1·8 from the occipital tuberosity, and 4·3 from the nasal spine of the frontal bone; glenoidal axes, if produced, would meet at ·1 behind anterior lip of foramen magnum. The palate is deep and narrow. Posterior lip of the external auditory meatus on the same plane as a point ·2 behind the anterior lip of foramen magnum. No posterior condyloid foramen.

6. A well-formed orthognathous, cryptozygous, almost sub-brachycephalic male Cranium, exceeding all the others in frontal height. It has a persistent frontal suture, a single parietal foramen, a narrow lachrymal bone, which on the left is synostosed to the superior maxilla. The anterior ethmoidal foramen proper to the frontal bone, a deep narrow palate, with a straight suture. Anterior palatine foramen very large; deep pterygoid fossæ. The spheno-parietal suture measures ·52 on the right, and ·4 on the left. The foramen magnum is placed 1·75 from the protuberance of the occipital bone, and 4·25 from the naso-frontal suture. The axes of the glenoid cavities would meet at ·35 behind anterior lip of occipital foramen. The line connecting the hinder margins of the external auditory meatuses lies ·1 in front of the last-named lines.

7. A large imperfect calvarium, with prominent frontal and parietal eminences; a wide flat norma verticalis; prominent occipital crest and protuberance, 2·1 in front of which is the foramen magnum, which is 4·3 from the naso-frontal suture. This is the skull of an adult male.

8. A moderate cryptozygous female skull, with a shallow depression in the left parietal bone, which is probably due to posthumous deformation, as described by Dr. Thurnam. Occipital protuberance elongated into a spine: a large posterior condyloid foramen is present. The left spheno-parietal suture measures only ·2; on the right the sphenoid bone is entirely cut off from the parietal by the temporal and frontal—a condition of rather rare occurrence, which is to be found once in about 120 skulls. The foramen magnum is situated 1·8 from the occipital spine, and 4·2 from the front of the nasal process of the frontal bone. Glenoidal axes meet ·07 behind the anterior lip of the foramen magnum; line from posterior edge of the external auditory meatus cuts off the anterior ·2 of the foramen. A depression exists at posterior fifth of the sagittal suture.

9. A phænozygous prognathous male skull characterized by a narrow keeled forehead, large mastoid processes, the anterior lip of the foramen magnum two lines below the level of the posterior, as in No. 3,

Vaginal processes prominent, basilar process thick but narrow, palate shallow, wide; spheno-parietal suture, ·5 on the left, and ·6 on the right. Foramen magnum 1·8 from occipital tuberosity, 4·2 from nasal spine of the frontal. Pyramidal process of palate bone extending for more than half the pterygoid fossa.

10. An orthognathous semiphænozygous Cranium, foramen magnum with the condyles projecting into it, and large; a line from the posterior border of the external auditory meatus of one side to its fellow of the opposite cuts off one-fourth of this opening. Sutures unclosed; glenoidal axes meeting at the anterior ·4 of foramen magnum; basilar process flat; occipital ridge large; a small rudimentary os lachrymale accessorium (Luschka in Virchow's "Archiv").

This skull likewise exhibits a nearly complete ossification of the pterygo-spinous ligament of Civinini. The spheno-parietal suture measures ·5 on either side. The foramen magnum is 2·1 from the occipital tubercle, and 4·25 from the front of the nasal spine of the frontal bone; the posterior inter-auricular line cuts the prolonged glenoidal axes at their point of meeting.

11. A very imperfect calvarium, spheno-parietal suture, measures ·5; marked by posthumous deformity.

12. Also imperfect; frontal bone ridged in the mesial line, spheno-parietal suture measures ·5. Foramen magnum is placed 1·9 in front of the occipital protuberance, and 4·3 from the nasal spine of frontal. Glenoidal axes meet at ·15 in front of foramen magnum; squama occipitis prominent; the upper half of the lambdoidal suture closed; the inter-auricular line cuts exactly the posterior border of the basilar process.

13. Is a series of detached, probably female bones, of which the frontal is moderate and flat, exhibiting no peculiarity; the combined parietals measure 6 inches across, so it must have been extremely brachycephalic; the occipital is small and flat.

14. Extremely imperfect; very prognathus in norma lateralis; nasal bones small; apparently the skull of an adult male; right spheno-parietal suture with a Wormian bone, an occurrence to be found about once in eighty skulls.

15. Oblong depressed in *norma verticalis* and phænozygous (Busk); *norma lateralis* displays maxillary prognathism, an appearance of depression on the left parietal (probably due to posthumous deformation); palatine arch deep and wide; occipital bone oblique; left side of squama prominent, the right a little flattened, probably also posthumous. This skull is that of an adult male. Spheno-parietal sutures are ·25 long.

The vomer does not come within ·5 of the level of the pterygoid plates, and thus the posterior nares appear as a single large opening. Foramen magnum shares in the general obliquity of the occipital bone, being bulged and crooked on the left side, and a little more straight on the right. The glenoid cavity is shallow, its axes, if produced backwards, would meet at the anterior lip of the foramen magnum, and the posterior

inter-auricular line cuts off the anterior ·3 of this opening. The foramen magnum is placed 1·6 from the occipital protuberance and 4·3 from the naso-frontal suture.

16. A prognathous phænozygous skull, measuring only 3·5 across front of forehead at the external angular process, and widening to 4·55 at coronal suture and 5·8 at the parietal eminences, with small close frontal eminences; spheno-parietal sutures 6 in length; foramen magnum particularly small, with flattened margins, measuring only 1·25 from before backwards; placed 1·9 from the occipital protuberance, and 4·15 from the naso-frontal suture. This skull is a female, and is remarkable as being essentially Eurycephalic; sutures are open; a small epactal bone is present; a trace of a frontal suture; the axes of the glenoid cavities meet ·15 in front of the foramen magnum. The posterior inter-auricular line is barely within the anterior lip of the foramen—palatine arches wide and flat.

This skull is broadly ovate from the peculiarity of measurement above mentioned.

17. An oval female skull with small spheno-parietal sutures; considerable degree of alveolar prognathism; a large foramen of Wenzel in the nasal bones; no parietal foramen nor left posterior condyloid foramen; arch of palate deep; *norma verticalis* cryptozygous. Occipital bone with "pneumatic" lateral processes (Hyrtl). Foramen magnum placed 1·8 in front of the occipital protuberance, and 4·4 from the naso-frontal suture. Spheno-parietal suture ·25 on right side, ·3 on left. A well-marked orthocephalus; the axes of the glenoid cavity, when produced inwards, meet at a point ·4 behind the anterior edge of the foramen magnum; the inter-auricular posterior line cuts the outer ·2 of the occipital foramen; the middle of the frontal is slightly ridged.

No. 16 presents to us the peculiar epactal bone described by Tschudi as characteristic of the crania of Peruvians, and called by him the os incæ (see an elaborate memoir Sur la Valeur de l'os epactal, by Jacquart in Robin's "Journal de l'Anat.")

In one of these skulls a Wormian or intercalary bone occurs in the spheno-parietal suture. Prognathism will be noticed as a distinct feature of these skulls; but it is mainly alveolar in its nature, true maxillary prognathism is only found in 3, 4, 5, and 15, while alveolar projection characterizes Nos. 1, 4, 5, 9, 14, 16, 17, reaching its maximum in No. 4.

As Prof. Huxley has shown that the so-called facial angle is the product of at least three unconnected factors, and thus exhibits nothing, I have not recorded this measurement for any of the Crania.

A number of lower jaws were also found, but are not appropriated to their respective calvaria. These I have examined and described separately. Many of them are characterized by strongly marked peculiarities, which makes their want of appropriation a matter of regret.

No. 1 is a small young jaw with an undeveloped last molar, a separate hole for the egress of the mylohyoidean branch of the inferior dental nerve. Digastric fossa very large and deep, higher up than usual, angles 3·3 apart; female.

No. 2 has a very prominent chin, is an adult jaw, the angles being 3·4 apart, probably male.

No. 3, a large wide male jaw, angles 3·8 apart. No. 4 has a very deep mylohyoidean groove, has flattened ground teeth; its angles are 3·6 apart; the width of the upper extremity across the condyle and coronoid process is 1·8.

No. 5 is wide and large, 3·8 from angle to angle, 1·6 across from condyle to coronoid process. No. 6 is small and broken. No. 7, an old jaw 3·8 wide at angles, 1·5 across extremity of ascending ramus.

No. 8, extremely large, 4·2 across from angle to angle, 1·5 across extremity of ascending ramus, it is undoubtedly the jaw of a powerful male.

No. 9, a fragment, small.

No. 10 is the jaw of a youth, the last molar not cut; the angles are 3·5 apart, and the condyle and coronoid process are 1·8 from before backwards.

No. 11, the jaw of an adult female; angles 3·7 apart, and the summit of ramus 1·4.

No. 12 has wide everted angles and deep muscular impressions; its ramus measures 1·6 across from before backwards opposite summit of coronoid process.

No. 13, width at angle 3·9; width across condyle and coronoid process 1·8.

No. 14, foramen for mylohyoidean nerve; very deep digastric fossæ; width between angles 3·5; width across condyle and coronoid process 1·4.

No. 15, a powerful "gorilla" jaw with large muscular impressions; width between the angles 3·8; teeth large and series complete, the alveolar arch forming a parabola of a very different curvature from the curve of the jaw itself, so that while the jaw angles are 3·8 apart, the last molar teeth are separated by an interval only of 2·5. The width across the summits of condyle and coronoid process is 2.

In collating these descriptions it will be noticed that the width of the jaw at the angle is extremely variable, ranging from 4·2 to 3·3. The width taken across the top of the ramus from the front of the coronoid process to the back of the condyle including, and to some extent corresponding to, the width of the sigmoid notch, varied likewise from 1·4 to 2.

XXVI.—Notes on the Felspars. By J. Emerson Reynolds, L.R.C.P., Edin., Keeper of the Minerals, and Analyst to the Royal Dublin Society.

[Read 12th May, 1869.]

In the course of last Session I had the pleasure of laying before the Society a Paper on the classification of the Anhydrous Mineral Silicates. In this paper the well-known theory of condensed silicic acids was used as a basis of classification. But I went much further than this, and sought to show that the condensation of the acid radicle of a silicate takes place at a fixed rate; and this rate of condensation was determined by the discussion of the formulæ derived from the best analyses of anhydrous mineral silicates. In a communication which dealt with the whole group of siliceous minerals it was obviously necessary to avoid entering much into details, but I hope now, from time to time, to be able to lay the results of the examination of special groups of minerals before the Society, and with your permission, will commence by discussing some points connected with the remarkable family of the Felspars, more especially since this is a group of minerals of considerable interest to the Fellows of this Society.

My object in the present Paper is, in the first place, to demonstrate, by means of some formulæ constructed on the plan proposed in my recent Paper on the Silicates, the profound chemical isotypism of the members of the Felspar group, and secondly, to give what I believe to be the true explanation of the cause of the wide variations in the proportion of silica observed throughout this otherwise strongly-marked series of minerals.

In the following remarks I am bound to assume that the reader is familiar with the system of notation and classification proposed in the Paper already referred to, which I had the honour of laying before the Society last Session.

I have already shown that the differences between the general formulæ of the Garnets, Epidotes, and Felspars, can be very easily appreciated if we write them in the following way:—

$$\text{Garnet} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (\tfrac{1}{2}R'^6 + \tfrac{1}{2}Al)^2 \begin{array}{ccc} & Si & \\ & \times & O_6 \\ & O_6 & \end{array}$$

$$\text{Epidote} \quad . \quad . \quad . \quad . \quad (\tfrac{1}{3}R'^6 + \tfrac{2}{3}(Fe,Al))^2 \begin{array}{ccc} & Si & \\ & \times & O_6 \\ & O_6 & \end{array}$$

$$\text{Felspar} \quad . \quad . \quad . \quad . \quad . \quad (\tfrac{1}{4}R'^6 + \tfrac{3}{4}Al)^2 \begin{array}{ccc} & Si & \\ & \times & O_6 \\ & O^6 & \end{array}$$

But in the cases of the Garnets and Epidotes, we have no reason to be-

lieve that the proportion of $\mathbf{Si}$* within the molecule of the silicate undergoes any natural variations. With the Felspars the case is quite different. Here we find three distinct sets of minerals, all agreeing in proportion of R', or monatomic metal to R^{vi}, or hexatomic metal, but varying in the ratio of $\mathbf{Si}$ to the basic constant, or, what comes to the same thing, in oxygen ratio. As a good example of the first class of Felspars I may take Anorthite. The formula of this mineral is—

$$\text{Anorthite} \quad . \quad . \quad . \quad . \quad (\tfrac{1}{4}Ca''^{3}+\tfrac{3}{4}Al)^{2} \begin{array}{ccc} \diagdown & \mathbf{Si} & \diagup \\ & \times & O_6 \\ \diagup & O_6 & \diagdown \end{array}$$

The oxygen ratio of a member of this first class of Felspars is, therefore, 1 : 1.

We now have the Felspars of the second class; and the best examples I can give are Leucite and Oligoclase, both minerals of practical importance—

$$\text{Leucite} \quad . \quad . \quad . \quad . \quad (\tfrac{1}{4}K^{6}+\tfrac{3}{4}Al)^{2} \begin{array}{ccc} \diagdown & \mathbf{Si}^{2} & \diagup \\ & \times & O_6 \\ \diagup & O_{12} & \diagdown \end{array}$$

$$\text{Oligoclase} \quad . \quad . \quad (\tfrac{1}{4}(Ca'', Na^{2})^{3}+\tfrac{3}{4}Al)^{2} \begin{array}{ccc} \diagdown & \mathbf{Si}^{2} & \diagup \\ & \times & O_6 \\ \diagup & O_{12} & \diagdown \end{array}$$

Here we have obviously a very different oxygen ratio, viz. 1 : 2, but the type remains unchanged; the molecule of the silicate is unaltered; it has simply condensed within it another atom of the anhydride $\mathbf{Si}O_6$.

As examples of the third class we have the two well-known minerals, Albite and Orthoclase.

$$\text{Albite} \quad . \quad . \quad . \quad . \quad . \quad . \quad (\tfrac{1}{4}Na^{6}+\tfrac{3}{4}Al)^{2} \begin{array}{ccc} \diagdown & \mathbf{Si}^{3} & \diagup \\ & \times & O^{6} \\ \diagup & O_{18} & \diagdown \end{array}$$

$$\text{Orthoclase} \quad . \quad . \quad . \quad . \quad (\tfrac{1}{4}K^{6}+\tfrac{3}{4}Al)^{2} \begin{array}{ccc} \diagdown & \mathbf{Si}^{3} & \diagup \\ & \times & O_6 \\ \diagup & O_{18} & \diagdown \end{array}$$

It will be now observed that the oxygen ratio has reached 1 : 3, but the true Felspar type is not merely still preserved but even appears now only to have reached its most complete development. Well ascertained facts seem to warrant the conclusion that the molecule of a Felspar of the first class is really incomplete until it has condensed

* This symbol represents what I believe to be the first stage of the condensation of silicon upon itself. The atomic weight of Si = 28 and of $\mathbf{Si}$ = 84.

within it two additional atoms of SiO_6 by successive stages; it has then reached its highest development.

Without seeking to force any analogy between the physical structure of a crystal and the chemical structure of a molecule, we may fairly borrow from the sister science of crystallography an illustration which may facilitate the comprehension of the difference between Felspars of the first, second, and third classes. In crystals belonging to the hexagonal system we frequently meet with regular six-sided prisms, which admit of indefinite prolongation in the direction of the unique axis; this is evidently an incomplete form. If, now, one of the planes making this a right angle with the unique axis be replaced by a six-sided pyramid, we have a definite termination for the crystal in that direction, and when the second plane is replaced by another pyramid the crystal is complete. If we take the simple prism as representing the Felspar of the first class, the prism with one termination as corresponding to that of the second class, and a complete crystal and a Felspar of the third class as being analogous to one another, we give some idea of the meaning to be attached to the terms employed in this Paper.

Having thus seen that we can group Felspars into three classes, it becomes a matter of much interest to attempt an explanation of the conditions which influence this remarkable, and yet methodic variation of the acidific portion of these minerals. In order to do this we may best contrast Leucite and Orthoclase, since both are potassium and aluminium silicates, differing only by the compound molecule SiO_6. Leucite, however, is a Felspar of the volcanic rocks, and Orthoclase of the granites. With the assistance derived from the known properties of the silicic acids, or as they are conventionally termed hydrates, and the Rev. Professor Haughton's valuable translation of Durocher's "Memoir on Comparative Petrology," I think it is possible to understand the conditions under which one or other of these Felspars can be formed, and the mode of production of either.

The silicic hydrates, as we may call them, are very unstable bodies, desiccation by heat of a hydrate $H^2\overset{Si}{\underset{O_2}{\times}}O$, at 100° C. being sufficient to convert it into the polysilicic hydrate $H^2\overset{Si}{\underset{O_6}{\times}}O$. The mineral Randanite of Salvetat appears to be identical with the latter body, for when completely dried at the ordinary temperature its composition is represented by the formula $H_2\overset{Si}{\underset{O_6}{\times}}O$; on drying at 100° C. for a long time, however, analysis now shows that it loses water, and becomes

$\begin{matrix} & Si^3 & \\ H_2 & \times & O. \\ & O_{12} & \end{matrix}$ Probably, on still further heating, a body corresponding to $\begin{matrix} & Si^3 & \\ H^2 & \times & O \\ & O_{18} & \end{matrix}$ would be obtained.

It is then easy to understand how a *silicic acid* may yield a *polysilicic acid* by simple loss of water (= base). But the permanent metallic base of a silicate cannot be removed as easily as the volatile water. Heating of the compound alone cannot alter it, notwithstanding the marked tendency of a silicate of a low type to pass into a polysilicate under the influence of heat; but the proportion of metal in a compound more than counterbalances the effect of a high temperature. The only mode of accumulation of silicon within the molecule of a normal silicate is then by the addition of silica from without.

Let us assume that a Felspar of the first class of the formula $\begin{matrix} & Si & \\ (\frac{1}{4}K^6+\frac{3}{4}Al)^2 & \times & O_8, \\ & O_8 & \end{matrix}$ is capable of existing in a semi-fused magma, it obviously cannot lose its basic elements unless some stronger affinity than that of SiO_6 comes into play; yet its tendency is to pass into its corresponding Felspar of the second class; i. e. into Leucite, which mineral would result from the addition of SiO_6 to the above group. Though it cannot undergo this change by loss of base, it can, and no doubt it does, by increment of acidulous radical; it will seize any silica which the necessity of the compound molecule enables it to displace from feeble combinations. The result of this is that the SiO^6 is, or its elements are, condensed within the molecule of the silicate, the tendency to accumulation of the polyatomic radical is partially satisfied, and Leucite is the result. Yet this is supposed to take place in the magma, which on cooling gives the volcanic rocks; and Durocher tells us, and numerous analyses prove amply, that these rocks are essentially basic, and comparatively poor in silica. It would appear, then, that the tendency of the acid radical of the ideal silicate to reach the second stage of condensation is sufficient to enable it to overcome the opposing influences around it in order that Leucite may be produced; but the cumulative power is not enough to enable it to pass into Orthoclase by the appropriation and condensation of the silica of other compounds. When we come to the granitic rocks, however, no such paucity of silica is observed; on the contrary, we have this body largely in excess, and the consequence is, that in these acid rocks we meet not with Leucite but with Orthoclase—a mineral in which the acid radical appears to have reached its greatest proportion, and the silica to have completely satisfied its tendency to accumulation within the molecule.

To sum up, then, we may fairly say that the results of this exami-

nation of the Felspar family are three in number.—1st. We see more clearly than before the profound isotypism existing throughout this remarkable natural group of minerals; 2ndly. We learn that the silica hitherto regarded on the one hand as *basic*, and on the other as *supplemental* or *accessory* silica in these minerals, is really present as the result of the partial or complete satisfaction of the tendency of the acid radical of the silicate to accumulate within the molecule of the compound; and, 3rdly. We see that the chemistry of *silicon* is more closely allied to that of *carbon* than many have hitherto suspected, for we find that when we apply the information derived from the careful study of the carbon acids and their salts, to the elucidation of similar compounds of silicon, we are able simply and satisfactorily to explain the variations in degree of acidity in such minerals as the Felspars, which the pure mineralogist has hitherto been unable to account for.

XXVII.—Report of Council.

[Read at the Anniversary Meeting, on February 10, 1869.]

At the close of this, the fifth year of the existence of the Royal Geological Society of Ireland, the Council have to congratulate the Society on the satisfactory condition of their affairs. Numerically, the ranks of fellowship have not diminished during the past year, and the Evening Meetings have been interesting and largely attended.

Within the past year we have lost one Fellow by resignation, and one by non-payment, and death has deprived us of one of our most active and valued members—Mr. George V. Du Noyer, of the Geological Survey, whose recent loss to science will be fresh in the memory of the Society. Mr. Du Noyer was elected a member of the Geological Society of Dublin in 1856, and was a contributor to the pages of our Journal on many occasions. His papers on the Geology of Kilkee, of Killarney, Caherconree, and of the cuttings on the Dublin and Belfast line of railways, evince his powers as an investigator, and his thorough acquaintance with the subject. The Council cannot let this opportunity pass without recording their deep regret for his sudden removal from amongst us.

We have gained two new Fellows by election to fill the ranks vacated by death and resignation.

Our meetings have been, as usual, the means of making public interesting investigations—Mineralogical and Palæontological. On the former branches of Geology, papers have been read by Professor Haughton, Dr. Reynolds, and Mr. Westropp. One of the most interesting facts reported by Professor Haughton was the discovery of Albite Felspar as a constituent of the Granite in Cornwall, which forms an interesting link in the series of investigation made under the auspices of the Royal Society of London and this Society by Professor Haughton, in connexion with the nature and origin of Granite. As a result of this series of researches, Professor Haughton infers that there are two

separate kinds of granite—metamorphic and intrusive—the former typified by the granite rocks of Donegal, Scotland, and Norway; the latter by the rocks of Leinster and Cornwall; and these he believes may be discriminated mineralogically, the intrusive granites being characterized by possessing albite; the metamorphic by containing lime felspars. Dr. Reynolds submitted to the Society analyses of specimens of Rutile, which are of interest, as they were the first examples of this mineral found in Ireland. He also laid before the March meeting a notice of the nature and mode of formation of those singular markings called Dendrites. The same gentleman read, at the May meeting, a sketch of a new classification of Silicates, based upon the model of the hydrates of silicic acid, in varying degrees of condensation, the water being replaced by different bases.

Our Palæontological papers have been few, but of considerable value.

Mr. Harte, the active and energetic surveyor of county Donegal, exhibited and described a singular organism, probably echinodermal, from the yellow Sandstone. At the same meeting a very interesting original collection of casts of Coprolites, from Lyme Regis, made by Dean Buckland, was presented to the Society by our President, the Earl of Enniskillen.

In Petrology our attention has been directed by Professor Haughton to the Axes of elevation in the Carboniferous Limestone of Lancashire, and he has worked out the interesting problem that these axes are easily explicable from simple mechanical principles. Lastly, our attention has been directed, by the valuable paper of Dr. Stokes, to the subject of the growth of Bog—a subject which is of great interest, either in a geological, archæological, or agricultural point of view.

R. Callwell, *Chairman*.

10th February, 1869.

In the Appendix will be found, as usual:—

I. A List of Fellows now on the books of the Society.
II. " " gained and lost during the year.
III. " Donations received during the year.
IV. " Societies and Institutions to whom a Copy of the "Journal" is regularly forwarded.
V. An Abstract of the Treasurer's Account for the year 1868.

APPENDIX TO ANNUAL REPORT.

No. I.

LIST OF FELLOWS, CORRECTED TO JANUARY 31, 1869.

Fellows are requested to correct errors in this List, by letter to the Hon. Secretaries, 35, Trinity College, Dublin; or to the Assistant Secretary.

OFFICERS OF THE SOCIETY FOR THE YEAR 1869-70.

PRESIDENT.—The Earl of Enniskillen, F. R. S.

VICE-PRESIDENTS.—Robert Callwell, Esq.; J. B. Jukes, M. A., F. R. S.; Colonel Meadows Taylor, M. R. I. A.; Sir Richard Griffith, Bart., LL. D., F. G. S.; Sir Robert Kane, M. R. I. A.

TREASURERS.—William Andrews, Esq., M. R. I. A.; Samuel Downing, LL. D.

SECRETARIES.—Rev. S. Haughton, M. D., F. R. S., F. T. C. D.; A. Macalister, M. D.

COUNCIL.—Gilbert Sanders, Esq.; Alphonse Gages, M. R. I. A.; B. B. Stoney, C. E.; Robert S. Reeves, M. A.; John Barker, M. D.; John Good, Esq.; Wm. Frazer, Esq., M. D., M. R. I. A.; Joseph O'Kelly, Esq.; J. Emerson Reynolds; George Dixon; Rev. H. Lloyd, Provost, T. C. D.; Alex. Carte, M. D., F. L. S.; W. S. Westropp, Esq.; Montagu H. Ormsby, LL. D., C. E.; C. R. C. Tichborne, Esq.; with the Honorary Officers.

HONORARY FELLOWS.

Elected.
1844. 1. Boué, M. Ami, For. Mem., L. G. S., *Paris.*
1865. 2. Burton, Capt. R. F., H. M. Consul, *Santos.*
1861. 3. Daubrée, M., Membre de l'Institut, 91, *Rue de Gréville, St. Germains, Paris.*
1861. 4. Delesse, M., Ingénieur des Mines, *Paris.*
1865. 5. Des Cloiseaux, M., Prof. of Mineralogy, *Jardin des Plantes, Paris.*
1861. 6. De Serres, M. Marcel, *Montpelier.*
1861. 7. Deville, M. C. Ste Claire, *Paris.*
1861. 8. Deville, M. H. Ste Claire, *Paris.*
1861. 9. De Koninck, M. L., For. Mem., L. G. S., *Liége.*
1861. 10. Geinitz, M. H. B., For. Mem., L. G. S., *Dresden.*
1863. 11. Hunt, Dr. T. Sterry, F. R. S., *Montreal.*
1844. 12. Lyell, Sir Charles, F. R. S., 73, *Harley-street, London, W.*
1861. 13. M'Clintock, Sir Leopold, R. N., 21, *Merrion-square, North.*
1844. 14. Murchison, Sir Roderick I., F. R. S., 16, *Belgrave-square, London, S. W.*
1832. 15. Sedgwick, Rev. A., F. R. S., *Cambridge.*

HONORARY CORRESPONDING FELLOWS.

1859. 1. Gordon, John, C. E., *India.*
1859. 2. Hargrave, Henry J. B., C. E., *India.*
1859. 3. Hime, John, C. E., *Ceylon.*
1858. 4. Kingsmill, Thomas W., *Hong Kong.*
1855. 5. Medlicott, Joseph, *India.*
1854. 6. Oldham, Thomas, F. R. S., *Calcutta.*

FELLOWS WHO HAVE PAID LIFE COMPOSITION.

1853. 1. Allen, Richard Purdy, 10, *Bessboro'-terrace, N. C. Road.*
1861. 2. Armstrong, Andrew, 16, *D'Olier-street.*
1857. 3. Carson, Rev. Joseph, D. D., S. F. T. C. D., *Trinity College.*
1857. 4. Dowse, Richard, *Mountjoy-square.*
1861. 5. Fottrell, Edward, 86, *Harcourt-street.*
1862. 6. Frazer, W., M. D., M. R. I. A., 124, *Stephen's-green.*

Elected.
1857. 7. Greene, John Ball, 6, *Ely-place.*
1857. 8. Haliday, A. H., A. M., F. L. S., M. R. I. A., *Harcourt-street.*
1848. 9. Haughton, Rev. Professor, M. D., F. R. S., 40, *Trinity College.*
1862. 10. Henry, F. H., *Lodge Park, Straffan, Co. Kildare.*
1850. 11. Hone, Nathaniel, M. R.. I. A., *St. Doulough's, Co. Dublin.*
1861. 12. Hone, Thomas, *Yapton, Monkstown, County Dublin.*
1831. 13. Hutton, Robert, F. G. S., *Putney Park, London.*
1851. 14. Jukes, Joseph Beete, F. R. S., 51, *Stephen's-green.*
1867. 15. Kane, Sir R., 51, *Stephen's-green.*
1834. 16. King, Hon. James, M. R. I. A., *Mitchelstown.*
1866. 17. Lalor, J. J., *Longford-terrace, Monkstown.*
1856. 18. Lentaigne, John, M. D., *Great Denmark-street.*
1848. 19. Luby, Rev. Thomas, D. D., S. F. T. C. D., *Trinity College.*
1851. 20. Malahide, Lord Talbot de, F. R. S., *Malahide Castle, Malahide.*
1867. 21. Malet, Rev. J. A., D. D., S. F. T. C. D., *Trinity College.*
1838. 22. Mallet, Robert, C. E., F. R. S., 1, *The Grove, Clapham-road, London.*
1846. 23. Murray, B. B., *County Survey Office, Downshire-road, Newry.*
1859. 24. Ogilby, William, F. G. S., *Liscleen, Dunmanagh, Co. Tyrone.*
1849. 25. Sidney, F. J., LL. D., 19, *Herbert-street.*
1864. 26. Symes, Richard Glascott, 51, *Stephen's-green.*
1851. 27. Whitty, John Irvine, LL. D., 35, *Lower Mount-street.*

FELLOWS WHO HAVE PAID HALF LIFE COMPOSITION.*

1854. 1. Barnes, Edward, *Ballymurtagh, Co. Wicklow.*
1866. 2. Bradley, Samuel, *Little Castle, Castlecomer.*
1832. 3. Bryce, James, LL. D., F. G. S., *High School, Glasgow.*
1862. 4. Carter, T. S., *Watlington Park, Watlington, Oxfordshire.*
1854. 5. Clemes, John.
1857. 6. Crawford, Robert, C. E., *care of Messrs. Peto and Betts*, 9, *Great George's street, Westminster, S. W.*
1861. 7. Crosbie, William, *Ardfert Abbey, Ardfert, Tralee.*
1866. 8. Duffin, W. E. L'Estrange, *Maghera Rectory, Co. Down.*
1861. 9. Dunally, Lord, *Kilboy, Nenagh.*
1832. 10. Dunraven, Earl of, F. R. S., *Adare, Co. Limerick.*
1866. 11. Ellis, R. H., *The Hill, Monkstown.*
1836. 12. Enniskillen, Earl of, F. R. S., M. R. I. A., *Florence Court, Enniskillen.*
1866. 13. Graves, S. R., M. P., *Wavertree, Liverpool.*
1853. 14. Harkness, Professor, F. R. S., *Queen's College, Cork.*
1861. 15. Harte, W., C. E., *Buncrana, Donegal.*
1856. 16. Haughton, Lieut. John, R. A., *Bengal.*
1850. 17. Head, Henry, M. D., 7, *Fitzwilliam-square.*
1858. 18. Hill, J., C. E., *Ennis, Co. Clare.*
1862. 19. Hudson, R., F. R. S., F. L. S., *Clapham Common, London.*
1865. 20. Jacob, Arthur, B. A., *Bromley, Kent.*
1839 21. James, Sir H., Colonel, R.E., F.R.S., *Ordnance Survey Office, Southampton.*
1832. 22. Kearney, Thomas, *Pallasgreen, Co. Limerick.*
1857. 23. Keane, Marcus, *Beech Park, Ennis, Co. Clare.*
1835. 24. Kelly, John, 38, *Mountpleasant-square, Rathmines.*
1853. 25. Kinahan, George H., 28, *D'Olier-street.*
1862. 26. Kincaid, Joseph, Jun., C. E., 9, *Spring-gardens, London, S. W.*
1838. 27. Larcom, Major-General Sir Thomas, R. E., LL. D., F. R. S., *Phœnix Park.*

* EXTRACT FROM BY-LAWS.

"Any person not residing for more than sixty-three days in each year within twenty miles of Dublin, shall be a Fellow for Life, or until he comes to reside within the above distance, on paying to the Treasurers the sum of £5 5s.

"Any non-resident Life Fellow who shall reside within twenty miles of Dublin for more than sixty-three days in any one year, shall cease to be a Fellow, unless he shall either pay an additional composition of £5 5s., or shall pay a subscription of 10s. 6d. for each year in which he shall so reside for more than sixty-three days."

Elected.

1858. 28. Leech, Lieut.-Colonel, R. E., 3, *St. James's-square, London, S. W.*
1840. 29. Lindsay, Henry L., C. E., *Melbourne, care of J. Bower, Esq., C.E.*, 28, *South Frederick-street.*
1867. 30. Meadows, J. M'Carthy, *Athy.*
1840. 31. Montgomery, James E., M. R. I. A.
1856. 32. Molony, C. P., Capt., 25th Regt., Madras N. I., *per Messrs. Grinlay and Co.*, 3, *Cornhill, London.*
1856. 33. Medlicott, Henry B., F. G. S., *Geological Survey of India, per Smith and Elder, Cornhill, London, E. C.*
1857. 34. M'Ivor, Rev. James, *Rectory, Moyle, Newtownstewart, Co. Tyrone.*
1865. 35. Morton, G. H., 7, *London-road, Liverpool.*
1845. 36. Neville, John, C. E., M. R. I. A., *Dundalk.*
1852. 37. O'Kelly, Joseph, 54, *Stephen's-green.*
1868. 38. Ormsby, Montagu H., LL. D., C. E., 16, *Fitzwilliam-square.*
1832. 39. Renny, Henry L., R. E., *Canada.*
1865. 40. Scott, J. M., *Bengal Presidency College, Calcutta.*
1868. 41. Siree, P. H., C. E., *Kelston, Stillorgan.*
1854. 42. Smyth, W. W., F. R. S., *Jermyn-street, London.*
1865. 43. Steele, Rev. W., *Portora Royal School, Enniskillen.*
1857. 44. Tait, Alexander, C. E., *Queen's Elms, Belfast.*
1832. 45. Tighe, Right Hon. William, *Woodstock, Innistiogue.*
1866. 46. Townsend, H. W., *Clonakilty.*
1866. 47. Wall, H. P., *Portarlington.*
1864. 48. Waller, G. A., *St. James's-gate.*
1858. 49. Webster, William B.
1861. 50. Whitney, C. J., *Brisbane, Queensland.*
1846. 51. Willson, Walter, 51, *Stephen's-green.*
1864. 52. Wright, Joseph, 7, *Donegal-street, Belfast.*
1854. 53. Wyley, Andrew, 51, *Stephen's-green.*
1857. 54. Wynne, Arthur B., F. G. S., 51, *Stephen's-green.*

ANNUAL FELLOWS.

1861. 1. Andrews, William, *Leinster-street, Dublin.*
1831. 2. Apjohn, James, M. D., F. R. S., *South-hill House, Blackrock.*
1867. 3. Baily, W. H., *Stephen's-green.*
1857. 4. Bandon, Earl of, D. C. L., *Castle Bernard, Bandon, Co. Cork.*
1859. 5. Barker, John, M. D., 83, *Waterloo-road.*
1861. 6. Barrington, C. E., *Fassaroe, Bray.*
1862. 7. Barrington, E., *Fassaroe, Bray.*
1862. 8. Barton, Henry M., 4, *Foster-place.*
1864. 9. Bateman, C. W., LL. B., *West End, Mallow.*
1859. 10. Battersby, Francis, M. D., 15, *Warrington-place.*
1844. 11. Bective, Earl of, *Headfort, Kells.*
1862. 12. Bennett, E., M. B., 2, *Upper Fitzwilliam-street.*
1857. 13. Bolton, George, Jun., 6, *Ely-place.*
1861. 14. Bolton, H. E., 6, *Ely-place.*
1864. 15. Bradshaw, G. B., 7, *Monkstown-crescent. Co. Dublin.*
1831. 16. Brady, Right Hon. Maziere, 26, *Upper Pembroke-street.*
1861. 17. Brownrigg, W. B., *Brannockstown, Co. Kildare.*
1840. 18. Callwell, Robert, M. R. I. A., 25, *Herbert-place.*
1857. 19. Carte, Alexander, M. D., F. L. S., *Royal Dublin Society.*
1867. 20. Clarke, G. R., *Public Works' Department, Lucknow, India.*
1862. 21. Close, Rev. Maxwell, *Newtownpark, Blackrock.*
1858. 22. Cotton, Charles P., C. E., 11, *Lower Pembroke-street.*
1862. 23. Cousins, A. L., C. E.
1834. 24. Croker, Charles P., M. D., 7, *Merrion-square, West.*
1863. 25. Crook, Rev. R., LL. D., 2, *St. John's-road, Sandymount.*
1853. 26. De Vesci, Lord, *Abbeyleix House, Abbeyleix.*

Elected.
1863. 27. Dixon, G., 32, *Holles-street.*
1849. 28. Downing, Samuel, LL. D., C. E., *Trinity College.*
1852. 29. Doyle, J. B., *Derrymore House, Newry.*
1867. 30. Dunscombe, Clement, *King William's Town, Co. Cork.*
1865. 31. Fleming, John M., *The Barracks, Clonmel.*
1866. 32. Foot, A. W., M. D., *Upper Pembroke-street.*
1867. 33. Forster, R., *University Club.*
1858. 34. Gages, Alphonse, M. R. I. A., 51, *Stephen's-green.*
1864. 35. Gahan, A., C. E., *Omagh.*
1849. 36. Galbraith, Rev. Joseph A., F. T. C. D., *Trinity College.*
1865. 37. Gibson, John, C. E., *Stapleton-place, Dundalk.*
1867. 38. Gore, J. E., C. E., 32, *Nelson-street.*
1865. 39. Gray, R. A., C. E., 5, *Palmerston Villas, Upper Rathmines.*
1859. 40. Green, Murdock, 52, *Lower Sackville-street.*
1862. 41. Gribbon, C. P., 72, *Stephen's-green.*
1831. 42. Griffith, Sir R., Bart., LL. D., F. G. S., 2, *Upper Fitzwilliam-place.*
1856. 43. Good, John, *City-quay.*
1857. 44. Hampton, Thomas, C. E., 6, *Ely-place.*
1866. 45. Heron, Robert, *Harrow House, Ballybrack.*
1861. 46. Hudson, A., M. D., *Merrion-square.*
1865. 47. Hutton, T. M., 118, *Summer-hill.*
1852. 48. Jellett, Rev. Professor, F. T. C. D., M. R. I. A., 9, *Trinity College.*
1842. 49. Jennings, F. M., M. R. I. A., *Broun-street, Cork.*
1862. 50. Kinahan, G., J. P., *Roebuck-hill, Dundrum.*
1866. 51. Knapp, W. H., C. E., 6, *Belgrave-square, Monkstown.*
1865. 52. Leech, John, C. E., 6, *Ely-place.*
1831. 53. Lloyd, Rev. Humphrey, D. D., F. R. S., Provost T. C. D., *Provost's House.*
1863. 54. Macalister, A., M. D., 13, *Adelaide-road.*
1855. 55. M'Causland, Dominick, 12, *Fitzgibbon-street.*
1861. 56. M'Comas, A., 23, *Rathmines-road.*
1865. 57. M'Donald, Alexander, C. E., *St. John's, Inchicore.*
1851. 58. M'Donald, John, M. D., 4, *Gardiner's-row.*
1837. 59. Mollan, John, M. D., 8, *Fitzwilliam-square.*
1859. 60. Moore, Joseph Scott, J. P., *Hume-street.*
1831. 61. Nicholson, John, M. R. I. A., *Balrath House, Kells.*
1856. 62. O'Brien, Octavius, 23, *Kildare-street.*
1865. 63. Ollis, G., *The Camp, Aldershott.*
1864. 64. Palmer, Sandford, *Roscrea.*
1865. 65. Porte, George, *Beggarsbush-road.*
1857. 66. Porter, William, C. E., *Leinster Club, Clare-street.*
1865. 67. Radley, John, *Gresham Hotel, Sackville-street.*
1864. 68. Reynolds, J. Emerson, *Royal Dublin Society.*
1857. 69. Reeves, R. S., 22, *Upper Mount-street.*
1861. 70. Roberts, W. G., *Nenagh, Co. Tipperary.*
1862. 71. Rowan, D. J., C. E., *Athlone.*
1864. 72. Russell, H., *Simmon's-court.*
1852. 73. Smith, Robert, M. D., 63, *Eccles-street.*
1852. 74. Sanders, Gilbert, M. R. I. A., *The Hill, Monkstown.*
1854. 75. Scott, Robert H., F.G. S., *Meteorological Office*, 2, *Parliament-street, London.*
1866. 76. Stewart, H., M. D., *Lucan.*
1859. 77. Stokes, William, M. D., F. R. S., 5, *Merrion-square, N.*
1861. 78. Stoney, Bindon, C. E., 42, *Wellington-road.*
1862. 79. Taylor, Colonel Meadows, M. R. I. A., *Old-court, Harold's-cross.*
1868. 80. Thresh, J. T., 2, *Old Palace, Richmond.*
1864. 81. Tichborne, C. R. C., *Apothecaries' Hall, Mary-street.*
1859. 82. Waldron, L., LL. D., *Ballybrack.*
1863. 83. Westropp, W. H. S., M. R. I. A., 2, *Idrone-terrace, Blackrock.*
1863. 84. Williams, Richard Palmer, 38, *Dame-street.*
1851. 85. Wright, Edward, LL. D., M. R. I. A., 10, *Clare-street, Dublin.*

ASSOCIATES FOR THE YEAR.

1. Clibborn, J., 13, *Leeson-park.*
2. Dwyer, F., 45, *Upper Sackville-street.*
3. Edmondson, J. W., *Foxrock.*
4. Greene, J. F., 63, *Lower Gardiner-street.*
5. Griffith, J. P., 2, *Trinity College.*
6. Hartrick, E. M., 2, *Trinity College.*
7. Heath, F., *Harold's-cross.*
8. Neville, E. K., 18, *Trinity College.*
9. Purcell, Gervase, 71, *Harcourt-street.*
10. Ryan, J. H., 34, *Leeson-park.*
11. West, C. D., *St. Patrick's Deanery.*
12. White, H. B., *Royal Dublin Society.*

No. II.

LIST OF FELLOWS GAINED AND LOST.

DURING THE YEAR ENDING JANUARY 31, 1869.

FELLOWS GAINED.

Half Life.

1. Montagu, H. Ormsby, LL. D., C. E., Geol. Surv., Ind., 16, *Fitzwilliam-square.*
2. Siree, P. H., C. E., *Kelston, Stillorgan.*
3. Wright, Joseph, 7, *Donegal-street, Belfast.*

Annual.

1. Thresh, J. T., 2, *Old Palace, Richmond.*

FELLOWS LOST.

Half Life.

1. Du Noyer, G. V., M. R. I. A., 51, *Stephen's-green.* Deceased.
2. Esmond, Sir Thomas, Bart., M. R. I. A., *Johnstown Castle. Wexford.* Do.

Annual.

1. Edgeworth, D. B., C. E., *Kildare-street Club.* Resigned.
2. Scovell, F., Blackrock. Do.
3. Trench, W. R., *University Club.* Do.

State of the Society at the commencement of—

	Year 1868.	Year 1869.
Honorary Fellows,	15	15
Corresponding do.,	6	6
Life do.,	80	81
Annual do.,	88	85
	189	187

No. III.

DONATIONS RECEIVED TO JANUARY 31, 1869.

Amsterdam.—Jaarbock van de Akademie van Wettenschappen, Gerestigd te Amsterdam, 1867.
Berlin.—Zeitschrift der Gesellschaft für Erdkunde, Nos. 13–18.
——— Zeitschrift der Deutschen Geologischen Gesellschaft, Vols. XIX., XX.; 1867–68.
Boston.—Memoirs of the Boston Natural History Society, Vol. I., Part 2, and Part 1.
Brussels.—Bulletins L'Academie Royal, des Sciences, des Lettres et des Beaux Arts, 1866.
Calcutta.—Asiastic Society of Bengal, President's Address, 2.
——— Memoirs Geological Survey of India, Vol. VI., Part 2; and Vol. I., Part 4.
Dublin.—Journal of the Royal Dublin Society, No. 37, 1868.
——— Pre-Glacial Man, and Geological Chronology. J. S. Moore.
——— Journal of the Historical and Archæological Association of Ireland, Vol. I., July, 1868.
——— Do., Vol. I., October, 1868.
Edinburgh.—Transactions of the Royal Scottish Society of Arts. Vol. VII., Parts 4, 5.
——— Proceedings of the Royal Physical Society, Session 1864-65.
Falmouth.—Report of the Royal Cornwall Polytechnic Society (36th Annual).
Glasgow.—Proceedings of the Natural History Society of Glasgow. Vol. I., Part I.
Haarlem.—Archives Neerlandaises des Sciences Exactes et Naturelles, 1868. Vols. I. and II.
Kilkenny.—Proceedings of the Kilkenny Archæological Society. Vol. V., No. 55.
Lausanne.—Bulletin de la Societé Vaudoise des Sciences Naturelles. Vol. IX., Nos. 54-59.
——— Do. Vol. X., No. 60.
Leeds.—Annual Report of the Leeds Philosophical and Literary Society, 1867–68.
——— Report of the Proceedings of the Geological and Polytechnic Society of the West-Riding of Yorkshire, 1868.
London.—Proceedings of the Royal Institute of Great Britain. Vol. V., Part 3.
——— Journal of the Linnean Society, Vol. X., Nos. 42, 43, 48.
——— Do. Vol. XI., No. 49.
——— Proceedings of the Royal Society, Vol. XVI., Nos. 102–104, 106, 107, 109, 110.
——— Journal of the Royal Geographical Society. Vol. XXXVII. (1867).
——— Proceedings, Do. Vol. XII., Parts 2–5.
——— Vol. XIII., Part 2.
——— Quarterly Journal of the Geological Society of London. Vol. XXIV., No. 95.
——— Vol. XXV., No. 98.
——— Report of the Meteorological Committee of the Royal Society for the year 1867.
Liverpool.—Proceedings of the Literary and Philosophical Society of Liverpool during the 55th Session, 1865–66.
Lyons.—Memoires de l'Academie Imperiale des Sciences de Lyons. Classe des Lettres. Tome Troizieme.
——— Memoires de l'Academie Imperiale des Sciences, Belles Lettres de Lyons, 1866–67.
Madrid.—Libros del Saber, de Astronomia del reg. D. Alfonso X. de Castilla.
Milan.—Reale Instituto Lombardo de Scienze E. Lettre, Rendiconti (24 Parts), 1867–68.
——— Solenni Adunanze del R. Instituto Lombardo di Scienze E. Lettres, 1867.
Montreal.—The Canadian Naturalist and Geologist. Vol. III., Nos. 3, 4.
Newhaven.—American Journal of Science and Art. Vol. XLVI., Nos. 133, 136-139.
Paris.—Nouvelles Archives du Museum D'Histoire Naturelle de Paris, 1867-68 (4 volumes).

Plymouth.—Annual Report and Transactions of the Plymouth Institution, Vol. III., 1868.

Shanghai.—Journal of the North China Branch of the Royal Asiatic Society. No. 4. 1867.

Toronto.—The Geological Survey of Canada; Report of Progress from 1863 to 1866.

———— The Canadian Journal of Science, Literature, &c. Vol. XII., No. 1; 1868.

Truro.—Journal of the Royal Institute of Cornwall. April, 1868.

Vienna.— Jahrbuch der Kaiserlich Koniglichen Geologischen Reichsanstalt, 1867–68 (5 Parts).

———— Verhandlungen der K. K. Geologischen Reichsanstalt, Jahrgang, 1868. Nos. 1–18.

Washington.—On the Fresh Water Glacial Drift of the North-Western States. By Charles Whittlesey.

No. IV.

SOCIETIES AND INSTITUTIONS TO WHICH THE JOURNAL OF THE ROYAL GEOLOGICAL SOCIETY OF IRELAND IS SENT.

ABERDEEN, .	University Library.
ALBANY, . .	State Library, New York.
AMSTERDAM, .	Royal Academy of Sciences.
ANTWERP, .	Société Palæontologique de Belgique.
BELFAST, . .	Queen's College Library.
BERLIN, . .	Royal Academy of Sciences.
	German Geographical Society.
	German Geological Society, per Bessersche Buchhandlung, *Behren-str.*, 7, *Berlin.*
BOLOGNA, .	Accademia delle Scienzi dell' Istituto.
BORDEAUX, .	Imperial Academy of Sciences.
BOSTON, . .	American Academy.
	Natural History Society.
BRISTOL, . .	Institution for the Advancement of Science, Literature, and the Arts.
BRÜNN, . .	Naturforschende Verein.
BRUSSELS, .	Academy of Sciences.
CAEN, . . .	Société Linnéenne de Normandie.
CALCUTTA, .	Asiatic Society.
	Public Library.
	Geological Survey of India.
CAMBRIDGE, .	Philosophical Society.
	Trinity College Library.
CANTERBURY, NEW ZEALAND,	Geological Survey.
COPENHAGEN,	Royal Society of Science.
CORK, . . .	Queen's College Library.
	Royal Institution.
DIJON, . . .	Academy of Sciences.
DRESDEN, . .	The "Isis" Society.
DUBLIN, . .	Royal College of Surgeons' Library.
	Royal Irish Academy.
	University Library.
	Royal Dublin Society.
	Natural History Society.
	Ordnance Survey Library.

DUBLIN, . .	Professor Sullivan, as Editor of the "Atlantis."
	Geological Survey of Ireland.
	Institution of Civil Engineers.
EDINBURGH, .	Royal Society.
	Wernerian Society.
	Royal Scottish Society of Arts.
	University Library.
	Society of Antiquaries.
	Advocates' Library.
FALMOUTH, .	Royal Cornwall Polytechnic Society.
FLORENCE, .	Society of Physics and Natural History.
GALWAY, . .	Queen's College Library.
GENOA, . .	Society of Physics.
GLASGOW, . .	University.
	Geological Society.
GÖTTINGEN, .	University.
HAARLEM, .	Société Hollandaise des Sciences, per B. Quarritch, 15, *Piccadilly, London.*
HALLE, . .	Naturwissenschaftliche Verein für Sachsen und Thüringen, per Antons Buchhandlung, *Halle.*
HANAU, . .	Oberhessische Gesellschaft der Natur-und Heil-kunde.
HANOVER, .	Royal Library.
KILKENNY, .	Archæological Society.
KÖNIGSBERG,	Königlich Physikalisch-Oekonomische Gesellschaft.
LAUSANNE, .	Société Vaudoise des Sciences Naturelles.
LEEDS, . .	Geological and Polytechnic Society of the West Riding of Yorkshire.
	Philosophical and Literary Society.
LEIPZIC, . .	Royal Society of Sciences (Saxony).
	University.
LIVERPOOL, .	The Literary and Philosophical Society.
	Historic Society of Lancashire and Cheshire.
	Geological Society, The Royal Institution, *Colquitt-street.*
LONDON, . .	Geological Survey, *Jermyn-street.*
	British Museum.
	Society of Arts, *John-street, Adelphi.*
	Royal Institution, *Albemarle-street.*
	Royal Society, *Burlington House.*
	Geological Society, *Somerset House.*
	Linnean Society, *Burlington House.*
	Royal Geographical Society, 15, *Whitehall-place.*
	Civil Engineers, Institution of, 25, *Great George's-street, Westminster.*
	Royal Asiatic Society, 5, *New Burlington-street.*
	Royal College of Surgeons, *Lincoln's Inn.*
	Zoological Society, 11, *Hanover-square.*
	Athenæum, 14, *Wellington-street, Strand, London, W. C.*
	Anthropological Society, 4, *St. Martin's-place, London, W. C.*
LYONS, . .	La Société Impériale d'Agriculture, d'Histoire Naturelle, et des Arts Utiles.
	Société Linnéenne.
	Academie Impériale, per Treuttel & Würtz, 19, *Rue de Lille, Paris.*
MADRID, . .	Academia de Ciencias.
MANCHESTER,	Literary and Philosophical Society of. [Sec., R. C. Christie.]
	Geological Society.
MELBOURNE, .	Philosophical Institute of Victoria.
	The Public Library, per Bain and Co., 1, *Haymarket, London.*
	The Royal Society.
MILAN, . .	Reale Istituto Lombardo di Scienzi.
MISSOURI, . .	State Survey and University, *Geological Rooms, Columbia, U. S. A.*

MODENA, . .	Institute of Science.
MONTREAL, .	Natural History Society.
MUNICH, . .	Royal Academy of Science (2 copies).
NEUCHATEL, .	Société des Sciences Naturelles.
NEWHAVEN, U. S. A.,	The Editors of Silliman's Journal of Science and Art.
NEW YORK, .	Lyceum of Natural History.
OXFORD, . .	Bodleian Library.
	Ashmolean Society.
PALERMO, .	Accademia di Scienzi e Lettere.
PARIS, . .	Ecole Polytechnique.
	Geological Society.
	L'Ecole Impériale des Mines.
	Institute of France.
	Bibliothéque Impériale.
	Jardin des Plantes, Bibliothéque.
PHILADELPHIA,	American Philosophical Society.
	Academy of Natural Sciences, per Trübner and Co.
PLYMOUTH, .	Plymouth Institution and Devon and Cornwall Natural History Society.
PRESBURG, .	Verein für Naturkunde.
QUEBEC, . .	Literary and Historical Society.
ROME, . . .	The Vatican Library.
ROUEN, . .	Academy of Sciences.
ST. ANDREWS,	University Library.
ST. LOUIS, . .	Academy of Sciences.
ST. PETERSBURG,	Imperial Academy.
	Central Physical Observatory of Russia.
	Russisch-Kaiserliche Mineralogische Gesellschaft.
STOCKHOLM, .	Royal Academy of Science, per Longman and Co., *Paternoster-row; London;* and Sampson and Wallis, *Stockholm.*
	Geological Survey of Sweden.
STRASBOURG,	Société des Sciences Naturelles.
STUTTGART, .	Verein für vaterländische Naturkunde.
TORONTO, C.W.,	Canadian Institute, per Thomas Henning, Esq.
TOULOUSE, .	Academy of Sciences.
TRURO, . .	Royal Institute of Cornwall.
TURIN, . .	Royal Academy.
UPSALA, . .	Royal Society of Sciences.
VIENNA, . .	Imperial Academy of Sciences.
	Prof. W. Haidinger, of Vienna, as Editor of the "Jahrbuch der K. K. Geologischen Reichs-anstalt."
	K. K. Zoologisch-botanische Gesellschaft, per Braumüller and Co., *Vienna.*
WASHINGTON,	Smithsonian Institute Library, per W. Wesley, Esq., 2, *Queen's Head Passage, Paternoster-row, London, E. C.*
WINDSOR, .	The Royal Library.
ZURICH, . .	Naturforschende Gesellschaft.

No V.

ABSTRACT OF TREASURER'S ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1868.

Dr.		£ s. d.
To Balance in Royal Bank, to December 31, 1867,	£8 7 5	
— Do., in Assistant Secretary's hands,	1 16 1	
		10 8 6
— Subscriptions received during 1868:—		
Life,	21 0 0	
Annual,	82 18 0	
Entrance,	3 8 0	
		107 6 0
— Dividends on Stock for half-year ended April 5, 1868:—		
On £234 14s. 7d.,	3 8 8	
Do, on do. for half-year to October 10, 1868, on £257 3s. 4d.,	3 13 7	
		7 2 3
— Balance due to Treasurers,	2 17 5	
	0 12 2	
		3 9 7
		£128 1 4

Cr.		£ s. d.
By Petty Expenses for 1868, viz.—		
Porter's Wages,	£12 0 0	
Servant's Allowance,	1 10 0	
Sundries,	15 11 8	
		29 1 8
— Salary of Assistant Secretary,		15 0 0
— Commission on Subscriptions to do.,		5 9 2
— Mr. Gill's Account for Printing,		25 0 0
— Extras do. do., &c.,		2 17 4
— Subscription for two years to Palæontological Society,		2 2 0
— Invested in Government Stock:—		
Life Composition, 1867,	26 0 0	
Do., 1868,	21 0 0	
		47 0 0
— Balance in Royal Bank, to December 31, 1868,		1 11 7
		£128 1 4

We have compared the foregoing Account with the Vouchers and with the Bank Books, and find it correct,

February 4, 1869. (Signed) SAMUEL HAUGHTON.
JOHN GOOD.

XXVIII.—On the Discovery of Albite Felspar, by Mr. Westropp, in the Granite of Dalkey, County of Dublin. By Rev. Samuel Haughton, Professor of Geology in the University of Dublin.

[Read November, 1869.]

The existence of albite, as the second felspar of the Leinster granites, has been long suspected by mineralogists and chemists, its presence having been inferred by Sir Robert Kane, from the large proportion of soda found in the analyses of the water springs issuing from the County Dublin granites.

The actual presence of albite crystals, however, in the granite rock was not proved until the discovery, by Mr. Westropp, during the course of last summer, of this mineral in blocks of granite forming the west pier of Kingstown Harbour. These blocks of granite came originally from the quarries of Dalkey. The albite occurs in small crystals in cavities of the granite, and encrusts other crystals of orthoclase; the crystals of albite are associated with similar small crystals of purple fluor spar, which were separated with difficulty from the albite crystals.

Mr. Westropp kindly furnished me with a quantity of the crystals, sufficient to perform an analysis, from which I obtained the following results :—

Albite Crystals (Dalkey).

		Oxygen.		Atoms.
Silica,	64·70	——	33·592	3·76
Alumina,	21·80	——	10·188	1·14
Soda,	9·78	2·508	2·978	1·00
Potash,	2·84	0·470		
Fluor spar,	0·80			
	99·92			

This analysis evidently represents albite felspar, and shows a slight defect in silica, and excess in alumina—errors which could scarcely be avoided in consequence of the small quantity of crystals that could be procured.

The discovery of albite felspar in the Leinster granites must be regarded as an additional link in the chain of evidence that connects these granites, geologically, with the granites of Cornwall and Mourne.

XXIX.—On Griffithides Mucronatus (M'Coy). By Ramsay H. Traquair, M. D., F. R. G. S. I., Professor of Zoology in the Royal College of Science, Dublin. (Plate XVI.).

[Read December, 1869.]

In the year 1844 M'Coy figured, under the name of *Phillipsia Mucronata*, the pygidium of a Trilobite from the Irish carboniferous limestone, and which he considered as new; remarking that he was acquainted with no other carboniferous form having the caudal extremity

prolonged, as in this instance, into a pointed spine or mucro.* But a trilobite, apparently the same as this, had previously been known to Continental observers under a different name; for, in 1840, we find Eichwald† mentioning a carboniferous trilobite from Bystriza, in the government of Novogorod in Russia, in which the tail is prolonged into a long pointed spine, and whose cephalic shield has on each side a long process. The name quoted for this species is *Otarion Eichwaldii* (Fischer); but the description is indeed sufficiently vague, and is not accompanied by any figure. However, in 1845, Verneuil,‡ in figuring and describing as "Phillipsia Eichwaldii," a pygidium, to all appearance belonging to the same species as the Irish specimen, put aside the name "mucronata" (M'Coy) as a synonym of "Eichwaldii" (Fischer). This example was followed by Bronn,§ and by Morris¶; and the remains of this species, not uncommon in many British localities, are at present very generally labelled and catalogued as *Phillipsia*, or *Griffithides Eichwaldii.*

On turning back, however, to Fischer's original description and figure of *Asaphus Eichwaldii*, from Vereia in the government of Moscow, published in 1825 ‖ we are surprised to find a *rounded* pygidium represented and described. The head is spoken of as unknown; but as regards the tail we read: "Cauda depressa, *subrotundato*, segmentis tredecim ad quatuordecim margine augustato, sulco infra profundo." Again, in 1837** the same pygidium was figured and described by Fischer. The figure looks as if it were taken from the same specimen represented in the former work, although the rounding of the caudal extremity is not here given so definitely, as altogether to preclude us from the idea that a spine might have been there, and had been broken off. What we *read* is, however, definite enough:—"La queue est subconique, *arrondie.*"

Can this, then, be the same species as that in which Eichwald, in 1840, says the tail is prolonged into a long spine? Is Asaphus Eichwaldii of Fischer really the Otarion Eichwaldii of Eichwald? De Koninck did not think so in 1842, for he gives Fischer's "Asaphus Eichwaldii," as a probable synonym of Phillipsia (Griffithides), globiceps (Phillips sp.), a well known species with rounded tail††. However, before saying anything more in answer to this question, it is necessary to investigate still further the literature of the pointed-tailed species.

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* Synopsis of the characters of the Carboniferous Fossils of Ireland, pl. iv., fig. 5.

† Die Thiersund Pflanzenreste des alten rothen Sandsteins und Bergkalks im Nowogorodischen Gouvernement. (*Bullet. scient de St. Peterb.* 1840.)

‡ Geol. de Russie 1845, vol. ii., p. 376, tab. xxvii, fig. 14.

§ Index Palæontologicus, Stuttgardt, 1848, vol. ii., p. 958.

¶ Catalogue of British Fossils, London 1854, p. 109.

‖ Contained in a work by Eichwald, entitled, "Geognostico-zoologicæ, per Ingriam marisque Baltici provincias, nec non de Trilobitis observationes." Casan, 1825, p. 54, tab. iv., Fig 4.

** Description des Animaux fossiles qui se trouvent dans le terrain carbonifére de Belgique, p. 600.

†† Oryctographie du gouvernement de Moscou, p. 120; pl. 12, Fig. 2, b, b.

In 1860, Eichwald* gave an entire figure of "Griffithides Eichwaldii," accompanied by a description more in detail than that which he published in 1840. The figure given in the Lethæa Rossica, will be seen, however, to present some marked discrepancies with those by which the present paper is illustrated. The cephalic spines are shown of enormous length, the eyes occupy a most remarkable anterior position, close to the margin of the cephalic shield; and more than one line or furrow crosses the central part of the head. The number of thoracic rings is 9, of axial segments in the pygidium, 18. No reference is made in the description to any ornamentation of the surface.

In 1867, Valerian von Möller,† in describing a pygidium of this species, from the neighbourhood of Tschernischkinaja, in the Government of Kaluga, in Russia, pointed out the delicate ornamentation of the surface, not before noticed as characteristic of the so-called Griffithides Eichwaldii. He criticised Eichwald's figure in the Lethæa Rossica with great severity, going even so far as to doubt its genuineness, and to suspect its being "a not quite successful restoration, in which the characters of two quite different forms occur—that of Phillipsia Mucroneta, and of another hitherto little known species." To this Trilobite, Möller restored M'Coy's name of "Phillipsia Mucronata," accepting Fischer's description of "Asaphus Eichwaldii," as applying to a round-tailed species.

That Eichwald would not permit an attack of this sort to pass unanswered, was to be expected; accordingly, we find him shortly thereafter replying vigorously to Möller's criticism,‡ maintaining in the first place, the genuineness of the figure in the Lethæa Rossica, which he states was taken by the clever lithographer, H. Kröger, from the same specimen as that mentioned in 1840. Maintaining the identity of Fischer's *Asaphus Eichwaldii* with the mucronate-tailed species under consideration, he asserts the presence of "a small depression or opening at the end of the middle portion of the abdomen in Asaphus Eichwaldii, which indicates a broken-off process." In the face, however, of Fischer's express statement, that the tail in his *A. Eichwaldii*, was rounded, outsiders will be rather disposed to look upon a careful re-examination of the original specimen as the only means of settling the question. Unfortunately, Eichwald goes on to remark, complaining that there is much disorder in the Museum of the Mining Institute of St. Petersburg, that it is said that the original of Griffithides Eichwaldii is no longer to be found. As it would seem that the specimen described by Fischer is here meant, I cannot see that in the circumstances anything else can be done, but to follow the example of Möller, in restoring

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* Lethæa Rossica, Formations anciennes, p. 1435, Atlas, pl. LIV., Fig. 10.

† Ueber die Trilobiten der Steinkohlenformation des Ural, nebst einer Uebersicht und einigen Ergänzungen der bisherigen Beobachtungen uber die Kohlentrilobiten im Algemeinen. Von Valerian von Möller; *Bulletin de la Societé imperiale des naturalistes de Moscou*, 1867, pt. i., p. 121.

‡ Die Lethæa Rossica und ihre Gegner: erster Nachtrag. Von E. von Eichwald. *Bulletin de la Soc. Imp. Nat. de Moscou*, 1867, iii., p. 202.

M'Coy's specific term of *mucronatus* to the trilobite, which is the subject of the present paper. It is also to be remembered that Fischer himself, having described in 1825 an undoubtedly round-tailed species as *Asaphus Brongniarti*, stated again, in 1837, that he did not consider it distinct from his A. Eichwaldii.

Mr. George Tate has described a mucronate-tailed trilobite, from the carboniferous limestones of Northumberland, under the name of *Griffithides Farnensis*.* I am indebted to Professor King for an opportunity of examining some of the Northumbrian specimens, which examination, along with a perusal of Mr. Tate's description, has convinced me that *G. Farnensis* is but a synonym of G. Mucronatus. Mr. Tate's diagnosis rests on the alleged smoothness of the pygidium in the latter species and its ornamentation by tubercles in the former. Having had, through the kindness of Sir Richard Griffith, an opportunity of examining M'Coy's original specimen, I can state that the smoothness of its segments is fully acounted for by the state of preservation in which it occurs as a fossil. Mr. Tate figures a small entire specimen, and gives a brief, though very accurate, description of its parts, especially of the head and pygidium; his drawing, however, cannot be said to be of a very finished or artistic nature. He is right in mentioning that Dr. Buckland in his "Bridgewater Treatise," figured a pygidium of the same species, from Beadnell, in Northumberland, under the wrong name of *Asaphus caudatus*.†

Having acquired some very illustrative specimens from the carboniferous limestones of Scotland, I am enabled to give a more complete description and better figures than any I have hitherto seen. Being imbedded in a soft argillaceous matrix, which, with the aid of water, can be easily brushed off, their surface markings are beautifully preserved and exhibited.

Fig. 1 represents the finest specimen in my collection, with head, thoracic segments, and pygidium in apposition; unfortunately, occurring as it did, just at the edge of a vertical joint of the rock, it is somewhat injured on the right side of the head and thorax. Its length is $1\frac{2}{7}$ inch. The *glabella*, or central portion of the head, measures $5\frac{1}{4}$ lines in length, it is moderately convex, and is separated from the lateral portions of the cephalic shield by a facial suture, or "eye-line," which follows the well known course of that line in this and allied genera. The well-marked neck-segment, or occipital collar, is separated from the glabella proper by a pretty deep transverse groove; and from this groove there extends obliquely forwards, on each side, at an angle of about 45°, a smaller lateral furrow, marking off a little triangular nodule, which extends towards the inner and hinder part of each so-called "eyelid." The rest of the glabella is convex, and bordered by a narrow flattened margin, continuous laterally, with the semilunar "eyelids." The entire surface of this central part of the cephalic shield is ornamented by fine

* Proceedings of the Berwickshire Naturalists' Club for 1856, p. 234.
† Bridgewater Treatise, 1836, pl. 46, fig. 11.

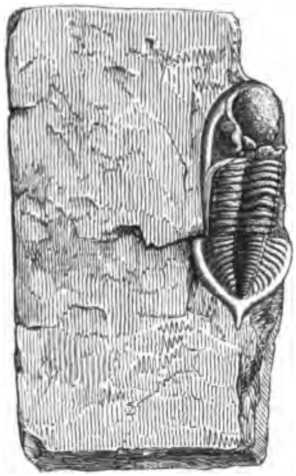


Fig. 1.

Fig. 6.

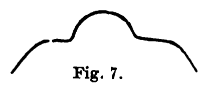


Fig. 7.

Fig. 5

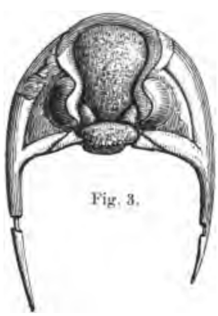


Fig. 3.

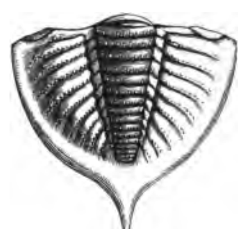
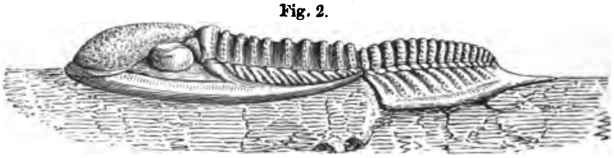


Fig. 4.

Fig. 2.



GRIFFITHIDES MUCRONATUS.—(DR. TRAQUAIR.)

granulations, except the anterior margin, which is minutely striated, as shown in fig. 3. At the posterior edge of the occipital collar, there is usually a more distinct row of these granulations (the first indication of the tubercles, which ornament the mesial lobes of the thoracic and caudal segments behind), and, immediately in front of these, there is in most specimens, though not in all, a slight median pointed elevation.

Each lateral portion of the cephalic shield presents a flattened, smooth, or slightly granulated internal area or cheek, nearly triangular, but with a large curved indentation at the position of the eye. The cheek is bordered externally and posteriorly by thickened rounded margins, which, uniting at the posterior external angle, are there produced backwards on each side into a long slightly pointed spine, as long as the glabella, and extending along the margins of the thorax as far back as the pygidium. In Eichwald's figure these spines are represented truly of tremendous length; while, on the other hand, Mr. Tate, in describing his *Griffithides Farnensis*, states that they only extend as far back as the sixth thoracic segment. The cephalic spines and the external border of the cheek-margin are adorned by numerous very delicate raised striæ, which sometimes anastomose with each other.

The prominent eyes are reniform in shape, and measure in the specimen represented in fig. 1, $\frac{3}{20}$ inch in length. In that specimen a minute facetting of the cornea is also distinctly visible with the aid of the hand lens.

The *thoracic segments* are nine in number; their general configuration, as shown in the detached one represented in fig. 6, is the same as that characteristic of the genera Phillipsia and Griffithides. On their lateral portions there are no markings beyond the usual groove and "facet," but the axial lobe of each is garnished at its hinder margin with a row of small tubercles. The axial lobes also slightly diminish in breadth from before backwards.

The *pygidium* is characterised, as M'Coy's name for the species implies, by its running out behind into a pointed spine or "mucro." In the specimen shown in fig. 1, it measures from the anterior margin to the extremity of the spine $\frac{7}{16}$ inch, and its base between the two anterior angles is $\frac{1}{2}$ inch, so that lines connecting those three angles of the pygidium form very nearly an equilateral triangle. The axial lobe contains sixteen segments,* each of which is ornamented by a row of small tubercles of a slightly elongated form; on the first segment I counted sixteen of these. The lateral lobes show each nine furrows (exclusive of the one immediately behind the facet), becoming more oblique in direction from before backwards; the nine lateral segments thus marked off are each ornamented by a row of tubercles, but these are very much more minute than on the axial segments. The lobated part of the pygidium is bordered by a somewhat flattened margin, finely striated externally, and increasing in breadth posteriorly, where it runs out into the mucro, this appendage measuring $\frac{3}{16}$ inch from base to tip.

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* The number of axial segments of the pygidium may vary from 14 or 15 to 18 (Möller).

Many authors consider that the genus *Griffithides* should be altogether abandoned, and its species merged in *Phillipsia*. In the present communication, however, I retain the name *Griffithides*, as, at least, a subgeneric title for those species which, like the one described, want the lateral glabellar furrows characteristic of the typical *Phillipsiæ*.

Griffithides mucronatus, though usually occurring in a fragmentary and disjointed condition, is one of the most characteristic trilobites of the carboniferous limestones of Northern Britain. My finest specimens are from the quarries of Ladedda and Wilkieston, near St. Andrews in Fifeshire, and I have also seen it from Newbigging of Craigston, in the same district. It occurs, also, on the coast near Elie; and in the Museum of Practical Geology in Jermyn-street, London, there are specimens from Falkland in Fifeshire, and from Kinesswood in Kinross. South of the Forth it occurs in the Lanarkshire district; it is recorded by the Geological Survey from Whitefield in Peebleshire; and I have found it near Dunbar in East Lothian. I am not aware that it is recorded from any other English county than Northumberland, where it occurs in many localities, as at Fosseland, North Sunderland, Denwich (Tate). The only Irish example which I have as yet seen is M'Coy's original specimen, which is from the carboniferous slate at Kildress, near Cookstown. On the Continent, it occurs at various localities in Russia, some of which have been already mentioned.

EXPLANATION OF THE FIGURES.

Fig. 1. Entire specimen of *Griffithides mucronatus*, but injured on the right side of the head and thorax. From Wilkieston, in Fifeshire. Nat. size.

Fig. 2. The same specimen seen from the left side, and magnified two diameters.

Fig. 3. Head of another specimen, × 2. From Ladedda.

Fig. 4. Pygidium from Wilkieston, × 3.

Fig. 5. Detached central portion of the cephalic shield, × 2. From Wilkieston.

Fig. 6. Detached thoracic segment, × 3. From Ladedda.

Fig. 7. Outline showing the form of a thoracic segment, seen from before or behind.

XXX.—Recent Gold Diggings in Scotland—A History and a Commentary.* By W. Lauder Lindsay, M. D., F. R. S. E., F. L. S.

[Read January, 1870.]

The Secretary of this Society (Dr. Macalister) having done me the honour of expressing a wish that I should continue my "Contributions to the Natural History of Gold and Gold Mining in Scotland," I willingly accept the invitation—because, on the one hand, the subject is invested with a vivid current interest in connexion with what is already known for years as "the Sutherland Gold Diggings; while, on the other, the more I study the subject, the more I am convinced of the desirability

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* It is necessary I should here explain that this paper was written in February, 1869, before the declaration of Kildonan as a "Gold-field," but while local interest regarding the auriferous riches of Sutherland was already intense and rapidly spreading.

of the public being presented, through our scientific societies, with trustworthy information regarding the probable distribution of gold in Scottand. As regards this question of the native gold of Scotland, the public appears to me too much divided into two opposite parties—the one too credulous, embracing in general terms the uneducated classes, the other the incredulous, including the majority at least of our men of science and letters. Of the credulity of the former, the "Fifeshire Gold Diggings of 1852" furnish us with a most instructive example—one which is partly sad, partly ludicrous. Of the incredulity of science the following illuslustration may suffice:—I very well remember that prior to giving myself the trouble of traversing Scotland to satisfy myself as to the probable extent and richness of its Gold-fields (having just returned from indubitable El Dorados, and having carefully examined many hundred specimens of gold and gold-rocks from all parts of the world, in various international exhibitions, home and foreign museums, and private mineral collections, as well as in the hands of gold diggers and buyers), I communicated with one of the very few mineralogists of whom our country can boast, a gentleman who holds a professional chair in one of our universities, who has made not a few original contributions to our native mineralogy, and who possesses what is probably one of the best private mineral cabinets in Britain; my object was to ascertain how far my anticipations and proposed investigation had been forestalled by others. I desired specially to become acquainted with the nature and extent of the labours of my predecessors in the same field, with all books and papers that had been published on the subject of gold in Scotland, and to see any accessible collections of Scottish gold and gold-rocks. This gentleman assured me that there were no books or papers on the subject, for the simple reason, that no native gold exists, or has existed, in Scotland; and he went so far as to caution me against entering on what he described as a "wild-goose chase!" You already know that, nevertheless, I did enter on the wild-goose chase in question. Some of the fruits of that chase I laid before this Society, others I hope in due time to have the pleasure of submitting. I may add that the truth of my conclusions is now being tested on the one hand, and confirmed on the other in Sutherlandshire. My friend the Professor wrote me:—"Scotland has been peopled for centuries by those who knew the nature of gold, Australia and New Zealand not so." This in answer probably to my argument as to presumptive evidence, based on similarity of gold-bearing strata in Scotland, and even richly auriferous antipodean colonies. The fallacy of the assertion that, if gold existed, it would long ago have been discovered and applied need not be pointed out here; it will sufficiently appear in the sequel. But the statement that no books or papers exist on the subject of gold in Scotland certainly exhibited a remarkable ignorance of mineralogical and national literature. Its author could have known nothing of Camden's "Britannica,"* Chalmers' "Cale-

* Six editions between 1586 and 1607.

donia,"* or Pennant's "Scotland,"† of Atkinson's "Gold Mynes of Scotland,"‡ or of Calvert's "Gold Rocks of Great Britain and Ireland,"§ and the numerous references and authorities it gives. I regard the statement of the Professor as a representative one, and only as such have I here introduced it. I have heard a similar opinion expressed by many other scientific men in Britain, who however have not studied the subject, and have had no personal experience in countries that are known to be richly auriferous. Experience leads me to prefer the actual essays of a man who has visited indubitable Gold-fields, and assisted in their development, to the mere dogmatic young savan writing from his library at home. Hence I have come to place a much higher value on the work of the digger than on the dicta of the untravelled man of science. Horace says very truly—

"Interdum vulgus rectum videt."

"Sometimes the vulgar see, and judge aright;" and as respects gold discoveries, we owe all of them, so far as I am aware, to the digger, the man of muscle and sinew, of indomitable enterprise and energy, happily possessed of that useful combination of faculties, generally known as "pluck." The geologist or mineralogist will in vain give his opinions as to the probable existence or amount of gold in a given locality, if there is no experienced digger to put the matter to the test. Sutherland is at present having the advantage of being examined by experienced gold diggers, men familiar with the auriferous rocks or drifts of Australia or New Zealand, California, British Columbia, or Nova Scotia.

If facilities were afforded by His Grace of Sutherland, or his representatives, it is probable we will in the course of time have the problem solved of the richness of the Scottish Gold-fields, in at least one of the Scottish counties, and the result of the experiment now going on in Sutherland will doubtless determine whether a repetition thereof is desirable in other of the many auriferous counties of Scotland. If the local proprietors grant the necessary assistance, and if the reputation of the Sutherland Gold-field proves such as to attract towards that county the numerous returned gold diggers, now to be found in every part of Scotland, there is every ground for expecting that the experiment of gold collection will be conducted on a scale fairly calculated to decide the question of its remunerativeness; and if the experiment is so conducted, it will be the first fair essay that has been made since the seventeenth century—the halcyon days of Bulmer and the Jameses—to show

* Three vols. 4to., 1807–24.

† "Tour in Scotland," 1774, p. 115 (a few notices only, and of no importance).

‡ "The Discoverie and Historie of the Gold Mynes in Scotland," by Stephen Atkinson, written in 1619, edited for the Bannatyne Club, in 1825, by G. L. Meason, 4to.

§ Including a "General Outline of the Gold Regions of the World, with a Treatise on the Geology of Gold," by John Calvert, of Australia, Mineral Surveyor: London, 1853.

whether, and how far, gold collecting is entitled to become a national or local industry in Scotland. It behoves all that are interested in the development of the mineral resources or the social progress of our country, to assist in a legitimate way the experiment now begun in Sutherland; and it is with a special view to such assistance that I venture now to offer certain general commentaries on gold digging—to discuss some general points connected with the discovery and development of gold-fields. For this purpose it will be convenient to select a text, whose lessons I may set forth; and it will, I trust, add to the interest of both text and lessons, if I select a brief history that is at once local and little known—one, moreover, that recommends itself to such a Society as yours, by exhibiting the results of the grossest popular ignorance of mineralogy and geology—I allude to the comparatively recent social revolution, once famous as the "Gold Diggings" (most erroneously so called) of Fife and Kinross-shires, in 1852.

For the main features of this most curious and instructive history I am indebted to my friend, Dr. Troup, of Auchtermuchty, who himself visited the Bishop's Hill (west Lomond) diggings, and who, in the "Fife Herald" of the day, took part in throwing the wet blanket over the gold fever of the Fife folk. I confine myself here chiefly to the scientific points involved; but I would recommend my hearers to read for themselves an account of the social aspects of our brief history as given (Dr. Troup tells me) by the late Rev. Dr. M'Kelvie, U. P. clergyman of Balgedie, Kinross-shire, in "Chambers' Journal" for July 24, 1852, p. 60, in an article entitled "Gold Seeking at Home." The same "stampede" has been the subject of a humorous story, in the Scottish vernacular, a story which has reached two editions, viz., "Joseph Spindle, his Life and Adventures, a Tale of the Gold-fields," 2nd edition: Edinburgh, W. P. Nimmo, 1859.

The "Lomond digging" mania occurred in May, 1852, and lasted about a month. There was a daily average of 300 diggers—at least 5000 to 6000 in all—many of them were earning 15*s.* per week, or upwards, who had thrown up their regular employment, to embark in the alluring lottery of gold seeking. The excitement extended over an area of twenty miles, including the opposite shores of the Forth of Tay. The gold fever reached its crisis on the fifteenth day, before noon, whereon at least 1700 persons were congregated on the west Lomond Hill. The origin of all this excitement "was the statement of a convict, a native of Kinnesswood, who wrote from Australia to the friends he had in the Kinross-shire village, that he had often seen gold at home at the lime quarries, above Kinrosswood, in the Bishop's Hill, similar to what was being dug in Australia" (Dr. Troup)*. Be it remembered, while we wonder at the ready credence which such a statement from such an

* In a letter to me, dated January, 1869.

authority found, that the public mind at the time was in a condition of double excitement, produced in the first instance by the brilliant auriferous discoveries in California in 1847, intensified and revivified by the no less splendid results of gold digging in Australia in 1851. Added to which, as Dr. M'Kelvie points out, there were certain floating local popular traditions or proverbs which gave a spurious weight or significance to the convict's rash assertion or conclusion. "The only result," says, again, Dr. Troup, "that followed was *nil* in the way of gold; but hosts of men, from all parts of Fife, starved themselves, and starved Kinnesswood, for three or four days—a loaf was sometimes bought for 2*s*. or 3*s*., and sometimes was not to be had at all." A hint this to the bakers of Sutherland, who, if they are wise, will lose no time in setting up stores in Upper Helmsdale, Upper Strathmore, and other of the auriferous glens of that presently famous county.*

The centre of attraction to the Fifeshire gold diggers, the chief scene of their labours, appears to have been a quarry of carboniferous limestone, variously known as the "Clattering," or "Clattering Well," "Sheethies," or "Sheethies-head" quarry, "right above the village, and north-west of Kinnesswood, in Kinross-shire, about a gunshot back from the brow of the Bishop's Hill," near its top. This locality is apparently on or about the south base of the west Lomond Hill, overlooking Loch Leven. Subjacent to the limestone, which is richly fossiliferous, is ochre interbedded with shale, according to Dr. M'Kelvie. This ochre abounds in globular masses of iron pyrites, known to the quarrymen as "fairy balls," from the size of a fist to that of a man's head. Incredible as it may appear, this iron pyrites was the substance dug out as gold by picks and trowels, and carried away in heavy quantities in pockets, wallets, and sacks, carried away too by men to whom it must have been quite familiar in the carboniferous strata of Fifeshire, the coal and iron miners of Loughgelly, Oakley, Dumfriesshire, &c.

"I wondered at the time," says Dr. Troup, "how the Loughgelly miners did not discover in the large crystalline masses of sulphuret what they must have been familiar with in shell gravel on a smaller scale!" Dr. M'Kelvie says, that koalena was also "firstly mistaken for gold; but it is scarcely credible that so palpable an error should have been committed, even under the immediate influence of the *auri sacra fames!*

A stupid local tradition about gold, or Larys Law, led a certain number of diggers to that source of basalt and trap-tuffe, capping old Red Sandstone, and standing in the midst of the carboniferous limestone and coal measures. What was mistaken for gold there is not stated, though the editor of the "Fife Herald" says, it "has more

* Two townships, of wooden huts or canvas tents, were subsequently established, one at Kildonan, "Bailanoir" (Anglicè, "Gold Town"), the other at Luisville, "Cathairnan Buth" (Anglicè, "Booth" or "Tent" town), each containing several stores, fully supplied with bread, meat, groceries, and miscellaneous wares.

appearance (judging from colour) of containing particles of the precious metal." Probably, it was again iron pyrites. Nevertheless, there appears to have existed great unwillingness to confess the error, and to suffer the delusion to be dissipated, that gold was an abundant product of the rocks of Fifeshire. Dr. Troup, who pointed out the true character of the yellow mineral, then so much in demand, says he "wrote a short note to the editor of the 'Fife Herald,' telling him what I thought of the gold. I can recollect that my opinion was doubted; for the note was inserted, with a *caveat* that I was an 'intelligent correspondent,' but the editor could not be responsible for the truth of my statements!"

Dr. Troup, however, writing me recently,* adds—"I have seen particles of gold, collected after much labour, from one of the Lomond streams in Glenvale; at least, that was the account given me by the old wife who had the 'Simon Pure' in her possession."

Calvert remarks—"The earliest allusion we have to the actual finding of gold in Scotland is about the close of the thirteenth century. David I. made a grant of a mine of gold in Fifeshire" (pp. 129 and 164). Calvert cites as his authority Tytler's "History of Scotland;" and Tytler apparently quotes in his turn, as his authority for the statement, John of Hexham, and the Chartulary of Dunfermline. Calvert goes on to make an even more questionable assertion, however, (p. 164)—"On the statement of mineralogists, gold is now found in the Fifeshire mountains." As his book was published in 1853, he wrote it, probably, in 1852, and during his inquiries in Scotland had, perhaps, heard of the "Fife diggings" above described. I am unaware of any mineralogist, of either recent or olden times, hazarding such an assertion. Nevertheless, it is by no means impossible—apart altogether from the evidence of Dr. Troup—that gold occurs in Fife or Kinross-shires, for it has been proved to exist in rocks of all kinds and ages. Forasmuch, moreover, as the Old Red Sandstone is formed from the *debris* of the metamorphic auriferous schist of the Highlands, it and the drifts or alluvial deposits produced from its disintegration, may also contain gold. Such is said to be the case at present in Caithness, gold having apparently been discovered there in not a few localities within the lower Old Red Sandstone area.‡

Among the lessons which may be drawn from the foregoing brief history of the Lomond diggings, and which are applicable to the present Sutherland diggings, are the following:—

Every now and then the public mind in Scotland is excited by the

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* Dated January, 1869.

† He further explains (in a letter, dated February 15, 1869), "the gold I saw was found on the Lomond, and was retained in the possession of my informant for many years. I inquired about it again; but the specimen had gone amissing, else I would have sent it to you."

‡ E. g. Berriedale Burn; Halkirk and Achdarradale, in the Thurso river; and Strath and Burn of Dunbeath (all in Caithness); Burn of Hester; Wick.

record in the newspapers of reported or real gold finds, sometimes in one county, sometimes in another. Sutherland is only the most recent instance. The "Scotsman," of February 24, 1868, under the head of a "Golden Discovery in Dumbartonshire," narrates how Duncan Ferguson, merchant, Alexandria, had just discovered, while boring for water, strata of apparently "rich gold quartz."

Now Alexandria is situated on the great belt of Old Red Sandstone that crosses Scotland westwards from between Stonehaven and the mouth of the Tay, apparently on the border-strata of upper flowerage, and represented respectively by the bed of Dura (Fifeshire), and Forfarshire—according to Murchison and Geikie's Map (1861). Though gold has been found in other countries in Devonian rocks, the Old Red Sandstone area in Scotland must be regarded—compared, at least, with the Silurian area of the Northern and Southern Highlands—as practically non-auriferous; so that such assertions as that in the "Scotsman," relating to Alexandria, require careful confirmation.* The same newspaper, of April 15, 1865—quoting from the "Elgin Courant"—says that a gentleman of Elgin had recently picked up a piece of auriferous quartz near Woodside. This was, probably, if the report was founded on fact at all,† a chip from a boulder, for apparently there is no quartz *in situ* in the district, the prevalent rocks of which are limestone and sandstone, of upper, lower, and middle Old Red Sandstone age. In my paper on the Gold and Gold fields of Scotland, I have given a third example—that of a gold find in Moffatdale, in 1863. Moffatdale differs, however, from the other localities of reputed gold-finds, being an undoubtedly auriferous area—Lower Silurian; and, moreover, we have Calvert's assertion that Griffin "prospected" it; and, as at Leadhills and St. Mary's Loch, found gold "everywhere."

The public excitement produced by newspaper reports of gold finds in Scotland is, fortunately, usually mild in its kind, and limited in its diffusion. It is mainly exhibited in, and confined to, the locality of the alleged discovery. But it does occasionally become so general as to lead to a "rush,"—such as that to the Lomonds in 1852, and to Kildonan in 1869. It would be an error to suppose that I place the gold diggings of Fife and Sutherland in the same category. There are several

* In reference to this reputed "find" at Alexandria, I wrote to Mr. Ferguson himself, who replied as follows (of date February 8, 1869):—"Mr. J. Ferguson begs to inform Dr. Lindsay that some workmen imagined that they had found (gold) quartz while digging for water; but on analysis no gold was detected. No further search was made." Doubtless many similar sensation reports regarding native gold are based on a similar amount of truth.

† The same district was much more recently (in the spring of 1869, about two months after the Helmsdale discoveries were made public) the scene of a gold mania similar in its phenomena to the Lomond diggings. There was a rush from Elgin to Lossiemouth to work gold from the bed of the Lossie on a Saturday and Sunday. The fruit of the diggings on this occasion was mica, and a profusion of local banter and amusement at the expense of the goldsmith diggers.

‡ I personally examined the whole valleys of the Moffat and Yarrow waters in August, 1869.

most important differences between them. In the first place Sutherland is, indubitably, an auriferous area; Fife is not. Secondly, there has been a great improvement in the general knowledge of the geology and mineralogy of gold, and of the theory and practice of gold working, since 1852. Thirdly, while now Scotland abounds in returned diggers, familiar with the gold fields of more richly auriferous countries, in 1852 this class of men may be said to have been unknown. And, lastly, the novelty of the brilliant discoveries in California and Australia produced an intensity of excitement that can never again exist in Scotland regarding native gold.

All that I can venture at present to say regarding the Sutherland gold field is that it deserves to be thoroughly prospected, for which purpose every facility ought to be given by the Duke of Sutherland to the experienced diggers, whose services it is now so easy to command. There is, probably, no better field in Britain for the proper conducting to its legitimate issue of the great current experiment for which fate appears to have selected it as the field; for this we have, so far, to thank the Ducal house of Dunrobin! Whether or not it was a mistake to make the now famous "Sutherland clearances" or "evictions," compulsory depopulation has left the county, in great measure, in a state of nature. But it would, I think, be an error in policy, and a subject of regret, not only to geological and mineralogical science in Scotland, but to all who take interest in the development of the industrial resources of our country, were the Duke of Sutherland to refuse diggers the necessary facilities for properly working the auriferous quartzites and drifts of that county. No digger will bestow labour and time, or risk the investiture of capital, unless he has what is, in regularly worked gold fields, known as a permanent "claim"—that is, a certain section of land which he is protected in working for his own benefit, by a document known as a "miner's right," or "license." It rests very much, therefore, with the Duke whether or not we are to be contented with the information already acquired—viz., that Sutherland is auriferous,—without obtaining that additional and more important knowledge—to what extent it is so!

Even in richly auriferous countries—where gold is to be found in substantial quantity—a "rush" to a new gold field, a new "diggings," is a serious social revolution, at all times to be deprecated. For a "rush" implies, as has already been seen in regard to Fife, and as may be read in the current local newspapers in regard to Sutherland —e. g. the giving up pleasant and suitable occupations for one that is at all times a lottery, and which is suited only to the robust and persevering—for dangerous exposure to the weather, without adequate provision either as to food or shelter—for the mental effects of disappointment and shame in event of non-success. In other words, there is, in the majority of cases, loss of work and work's worth—wages—with exposure to cold, wet, and hunger, and thereby to the risks of disease

and death.* Even the able-bodied and skilled digger is not uniformly successful in the richest gold field. The stalwart Scotchman, who emigrates to Australia or New Zealand, and labours for years at their diggings, after acquiring suitable knowledge by experience, may return as poor as he went, and this from no fault of his own. No occupation is so uncertain in its results as gold mining. Of adjoining "claims" on a gold field, one may yield, even in a day, a fortune to its possessor,† while the other may prove a loss; so local and fickle are the deposits of gold, whether in drifts or quartzites. If this be the case as regards professional diggers, what result is to be expected from digging by persons utterly unskilled, and physically unsuited to one of the most fatiguing of mechanical occupations? Can it be matter of surprise that so many persons should return empty-handed and disgusted? But this is not, perhaps, the most serious result of gold digging by unsuitable persons; for the class referred to is largely made up of those who become "loafers," idlers, hangers-on, who hamper the labours of the skilled and suitable digger. They watch all his movements, interfere with all his operations, and, if permitted, will even appropriate any of the benefits that may accrue from his exertion. From this class of persons, who may be called the predatory class, the *bêtes noires* of our gold-fields, the experienced digger must be protected, or all real interest in his work is impossible; and without this real interest, earnest labour need not be expected.

When we read the accounts of "rushes" to the digging by distant colonies, we are apt to flatter ourselves that such a state of matters could not exist in "douce" Scotland, amongst its shrewd, cautious, stolid peasantry. But that we err grievously in laying such "flattering unction to our souls," is proved both by the Fife and Sutherland diggings; the measure of the excitement generated, and an indication of its kind, may be found in the utter disregard of Sabbatical rest by the miners and weavers, shepherds and ploughmen of Fifeshire, at the Lomond diggings of 1852, and the Lossiemouth "rush" of 1869—a measure this, however, that can only be thoroughly appreciated by Scotchmen familiar with the usual strict observance of the Sabbath in their native land. On any gold-diggings I have visited in New Zealand, I found Sunday observed as a day of rest from all usual toils or occupations;‡ so that, in this respect, the comparison tells unfavourably as regards Fifeshire and Morayshire. The Lomond diggings' history shows

* These remarks apply more particularly to the early history of gold fields in our antipodean colonies. When gold mining becomes a permanent local industry, townships spring up, and bring with them all the advantages of civilized life.

† The most recent and striking illustrations of this fact are to be found in the Thames gold field of Auckland, N. Z., whose auriferous capabilities I ventured to predict in 1862.

‡ The same may be said of the Kildonan diggings of 1869. The old kirk of Kildonan, renovated for the purpose, has contained as regular and orderly congregations of diggers as it ever did in the most halcyon days of its pristine rural quietude.

what a power superstition or tradition still has over the uneducated popular mind; while Sutherland at present furnishes daily examples of the rise and wonderful and rapid exaggeration of unfounded or ill-founded rumour, and of the invention of stories calculated to illustrate rather what is desired to be, than what is, the fact. In truth, we are forced to the conclusion that our own countrymen, in their own country, are only too susceptible to the infection of the dangerous epidemic that has, in one sense happily, been termed "the gold fever;" and that, even among ourselves, a "rush" to a gold digging promises to be attended or followed by the same anarchy and rebellion—misery and disease—vice and crime—that are too frequently its accompaniments in all auriferous countries.*

This being the case, it appears to me to be at once the duty and policy of Government, when a rumour arises that threatens to become wide-spread, as to the discovery of gold in Scotland, in the first place to take steps for a reconnaisance survey of the alleged auriferous district, by a geologist, assisted by an experienced gold digger and a suitable staff of labourers. The public mind should at once be satisfied as to the amount of truth contained in such startling announcements regarding (e. g. the Sutherland) gold finds, as have recently occurred in all the Scotch newspapers. At present there is no test of the truthfulness of public rumours anent gold discoveries. Our peasantry, and, much worse, our "roughs," may "rush" a locality in search of gold, no provision being made for the establishment or maintenance of public order, peace, or honesty, or even for the barest necessaries of shelter and food. The gold fever may reach a considerable height in its influence on the social relations of a county or district before any steps are taken to prevent or mitigate the miseries that cannot fail to attend it. In many cases, a simple authoritative assertion that a given district contains no gold, or none worth working—or that a given substance is a worthless ore of iron or copper, or mere scales of mica—would suffice to allay excitement, prevent all speculation, and retain the energies of many able-bodied members of society in the handicrafts for which they are better suited alike by habit, taste, and experience. When a "rush" does occur, or threatens to do so, provision is imperatively requisite for food and shelter, for the administration of justice, and the repression of crime. Such provision is promptly made in our auriferous colonies, on the discovery of every new gold field. But the cases are not quite parallel; for it is the object of colonies to attract population, and arrangements are made for comfort, justice, and the common weal, of a kind, and to an extent, that cannot be claimed or expected, at least on the same ground, in the mother country, whose object is rather to promote emigration; and where it is too frequently the practice of the great landowners to depopulate for the mere value of game.

* Kildonan subsequently proved a remarkable exception to this general statement, in so far as there has reigned throughout a conspicuous degree of sobriety and harmony among the diggers.

While it is, I think, the duty of government to protect the personal interests of society or a gold-field, and the policy of local proprietors to aid the efforts of men of influence in gold-digging, who are willing to venture their time, skill, labour, and capital, in gold-searching and collecting in Scotland, the searching and collecting in question may be greatly furthered, as in all auriferous countries, by co-operation of effect and concentration of capital; in other words, the limited liability company system may be applied with good advantage to gold-mining in Scotland, in the first place, as an experiment—assuming always that government and the local proprietors give the necessary protection to the interests of the shareholder. While I doubt very much whether many men of science or of trade unacquainted with gold-digging will embark capital in what must be at first a mere experiment, I have little doubt that a sufficiency of returned gold-diggers and colonists from auriferous lands might be found to set the experiment going to an extent that might demonstrate in some measure how far it will or will not pay in Scotland to work gold. I venture, however, to add that any such experiment, if it has not the benefit of capital from scientific men in this country, should at least have their patronage and encouragement.

On the Lomond and Helmsdale diggings, I hear that several native minerals are mistaken for gold.* In Fife it was *iron pyrites*, while in Inverness and Monally *mica* was, or is, confounded with gold. Nor are these errors confined to Scotland; they have occurred in *all* auriferous countries (e. g. in Nova Scotia), and in many countries that are not auriferous. Copper and lead pyrites also belong to the category of native minerals mistaken for gold. Some of those substances are occasionally themselves auriferous—e. g. iron and lead pyrites, but generally so sparingly, that if the extraction of the gold is remunerative at all, it can only be so in the operation of smelting on the large scale for the more valuable products, iron and lead. The amateur gold-buyer may, however, be imposed upon by a base of artificial gold or gold-mica substances—" Brummagem goods;" that includes spelter, brass, pinchbeck, Abyssinian gold, and aluminum bronze. In the form of filings or artificial nuggets, they may easily be passed for gold among persons who can impose upon themselves with iron pyrites or mica. A hint this for those who are ordering jewellery of Kildonan gold—jewellery for which there appears to be already a great demand.†

Technical and scientific education, when it has become *un fait accompli*, and has been placed at command of all classes of the people, will do much towards the prevention in future of such social epidemics as that of Bishop's Hill, by diffusing at least an elementary knowledge

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* This was specially pointed out in an article, headed " All is not Gold that Glitters," in the " Northern Ensign" for July 1, 1869.

† It is largely advertised by the jewellers of Inverness, and is manufactured also in Edinburgh and Glasgow.

of geology and mineralogy, of the commoner rocks and minerals of our country; and it is, I think, one of the strongest arguments in favour of the necessity for, and advantage to arise from such education, that such scenes as the Lomand diggings can occur in our own times.

In a recent biography of the late Professor Forbes,* I was struck with the opinion of both these distinguished geologists as to the decadence of Scottish geology. I venture to assert that this cannot arise from want of proper fields to direct the energies of our rising geologists. Our knowledge of the distribution of gold in Scotland is (e. g.) most defective. No light has been thrown on the subject for a couple of centuries. We cannot be said to know anything definite of the auriferous drifts or quartzites in Scotland, and of the important and vast subject of the drift in general, and of the superficial strata subsequent to the formation of the secondary rocks, and to the last general submergence of Scotland. Our information is both meagre and confused. I know of no investigation in Scottish geology that promises to be at once more difficult or more interesting than that which attaches to the tertiary and post-tertiary strata of Scotland. Some of the difficulties that have occurred to myself connected with such an investigation I may describe at some future time, under the heading of "The Auriferous Drifts of Scotland."

XXXI.—On Spheroidal Structure in Silurian Rocks. By Rev. J. D. La Touche. (Plates XVII., XVIII., XIX., XX.

[Read January, 1869.]

It will hardly be necessary to remind those who have studied the Silurian strata that spheroidal masses are met with in them of almost every size, sometimes deeply imbedded in the stone; at others an entire mass of rock is arranged with reference to a spherical contour; sometimes the imbedded nodule is a hard calcareous kernel; at others, especially where it is of great size, there is little or no difference between its character and that of the rock which surrounds it.

It may be desirable to specify these varieties of structure more accurately.

The Wenlock shale affords a very marked example of it. In this formation either a multitude of smaller nodules are found irregularly dispersed throughout, or, as at Wenlock Edge, and elsewhere, long lines of them are arranged with the regularity of bricks in a wall.

These nodules are more or less calcareous, and are imbedded in the surrounding shale. They give the impression of an original uniform deposit of limestone having been broken up, or rather rearranged in this form. That fossils may have determined the position of the nodules may be doubted from their great regularity, and because that, on

* By Archibald Geikie, F. R. S., Director of the Geological Survey of Scotland.

splitting them open, it is rare to find any trace of organic remains in them.

We must not omit to observe here those remarkable accretions of limestone found at Wenlock Edge, Dudley, and elsewhere, locally called "ballstones," which are so extensively used for the iron works of the neighbourhood. They vary in size, from a few feet to some hundreds of yards in diameter, and are for the most part of irregular shape. As represented in figs. 1 and 2, they have in the process of formation evidently caused a disturbance or dislocation of the adjacent rock. In all instances that I have had occasion to examine them this has been the case. They generally extend too far below the exposed surface to enable the underlying strata to be seen; but the overlyin grock is invariably arched, and pushed up out of its natural position by them, and where it can be examined they are not very large. The subjacent rock is found to be so also. In many cases the rock on each side of them is seen to enter the mass of ballstone, and its stratification to be, as it were, lost in it.

In the above instances the nodule consists of a distinctly different kind of stone to its matrix, having for the most part a high percentage of lime. In the examples which follow, such is not so strikingly the case, although there is no marked line of demarcation between the two kinds of structure.

I have before me a piece of lower Caradoc sandstone, a few inches square, of which fig. 3 is a rough drawing. The central part consists of a bluish-grey micaceous and somewhat argillaceous sandstone, of an oblong, rounded shape, and around it are three rings of alternately yellow and blue coloured sandstone; apparently the yellow bands are somewhat more sandy and micaceous than the blue ones, while the interior mass is somewhat round; the nearer each of the rings is to the surface of the block the more nearly does it correspond with its shape. This fact is still more strikingly seen in figs. 4 and 5, where the shape of the fragment is still more irregular, two of its faces being prolonged to an acute angle. The discoloration here corresponds generally with the surface of the fragment; but is more spherical towards the centre, and upon again splitting open one of the two pieces into which the whole was divided, a nodule corresponding in shape with the weather stain was exposed to view (fig. 5).

Lastly, there are instances in which there is no apparent difference whatever between the character of the nodule and the surrounding rock, and yet its spheroidal structure is not less distinctly marked (fig. 8).

At the southern extremity of the Longmhynd range, in the construction of the railway from Craven Arms to Bishop's Castle, a considerable cutting exposed a most interesting section of the lower purple Wenlock beds. Some four or five years have elapsed since then, and the strata are to be seen at the present time in a state of semi-decay, very favourable for examining their situation. Before long they will have assumed the monotonous slope of the usual railway embankment.

Fig. 1.

Fig. 2.

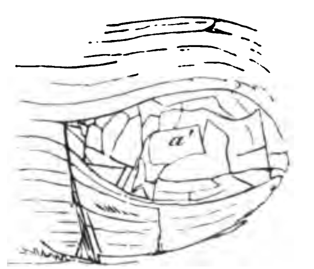


Fig. 3.

SPHEROIDAL CONCRETIONS.—(Rev. Mr. Latouche.)

Fig. 4.

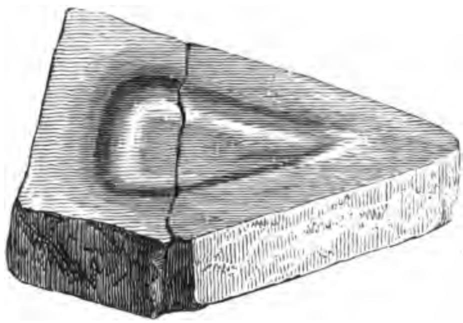
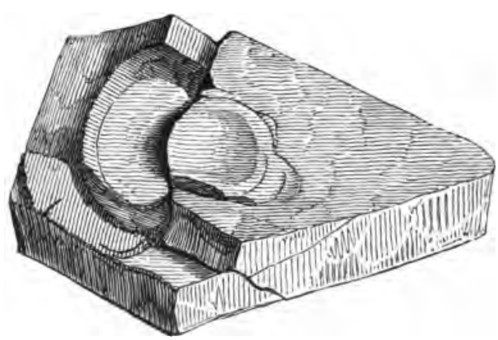


Fig. 5.



SPHEROIDAL CONCRETIONS.—(Rev. Mr. Latouche.)

Fig. 6.

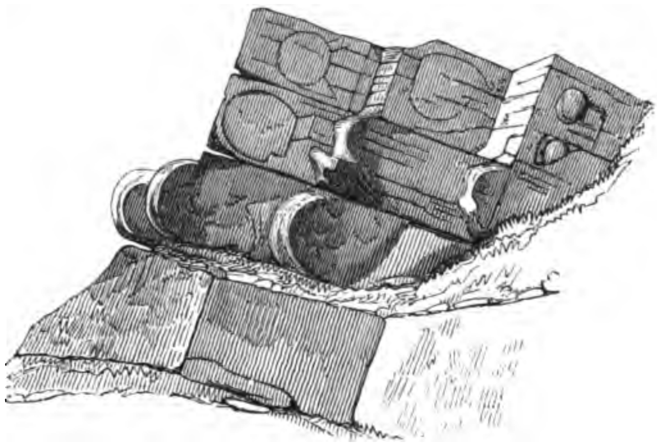


Fig. 7.

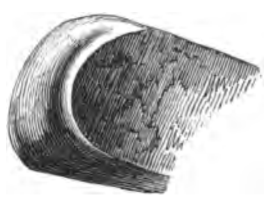
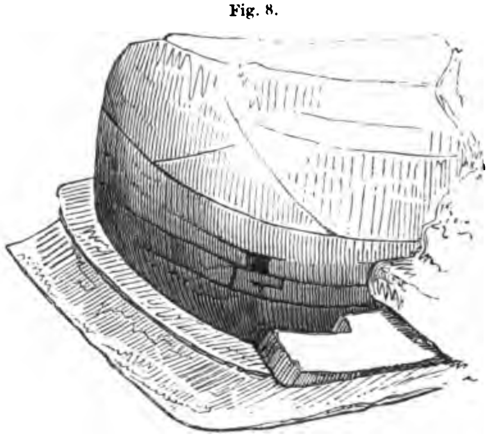
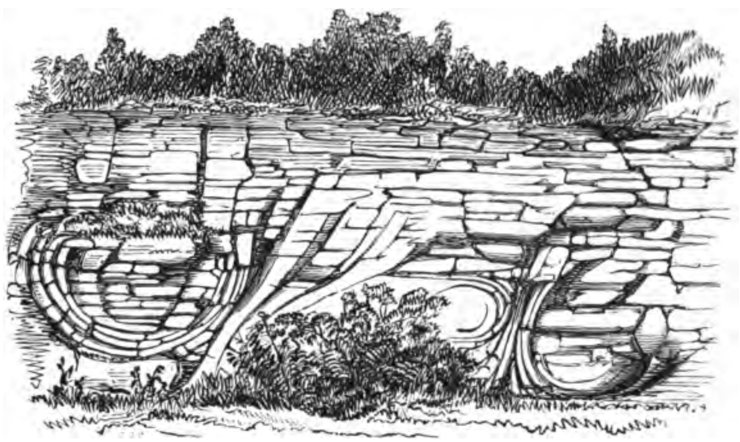


Fig. 8.



SPHEROIDAL CONCRETIONS.—(REV. MR. LATOUCHE.)

Fig. 9.



SPHEROIDAL CONCRETIONS.—(Rev. Mr. Latouche.)

In the meantime the projecting masses of shale present a very interesting object of study, both as to their fossil contents and as regards their structure. It may be observed, that before entirely falling to pieces these blocks of stone almost invariably assume a spheroidal aspect (fig. 6), shown in detail in Fig. 7. In some cases the original sharp edges and angles of the rock are yet preserved, in others some portions have been removed, while in others a perfect spheroid has been exposed to view, the origin of which may, however, be traced in other as yet undecayed blocks, sketched out as it were in fine lines on the surface of the stone.

In every direction may be seen in this railway cutting the indications of nodular structure, embedded in large cubical masses of rock, sometimes of the diameter of two or more feet, sometimes of as many inches. Like the statue which the sculptor imagines to be imprisoned in the shapeless marble, and which he hastens with skilful chisel to reveal, these spheroidal masses exist in the primeval rock, awaiting the inevitable hand of time, acting through atmospheric agents, to bring them to light.

Besides these more irregularly placed masses, there may also be seen at the same place, in the purple beds, those regular, almost brick-like, layers of nodules which I have before alluded to as being so characteristic of the Wenlock shale in this neighbourhood.

Now the question remains to be considered, what is the cause of this structure? It does not, as far as I am aware of, exist where slaty cleavage is very marked, but where the general character of the rocks is somewhat crystalline or rhomboidal. There it seems to abound. In many of the instances last referred to the joints of the stone are continued through the spheroids unaffected by this curved structure (figs. 6, 8, and 9); in some cases the curved structure assumes the form of concentric layers, like the coats of an onion (figs. 8 and 9), and yet the general stratification of the external rock is continued through them when not interrupted by the lines of curvature. This is seen in a very beautiful example on the Whitcliffe, near Ludlow, of which fig. 9 may give some idea. Here it would seem that the position of the three more prominent spherical masses was determined by the occurrence of the somewhat parallel faults, which run obliquely from the top of the right-hand side of the section to the bottom of the left.

Has this peculiar structure we have been considering been the result of an accumulation of calcareous matter at particular spots where the whole stratum in which they are found was deposited? or is it the result of subsequent action?

The occurrence occasionally of a hard calcareous kernel in the centre of a large spheroid, such as that in fig. 8, might lead to the inference that the diffusion of its lime has in some way determined a fresh arrangement of the particles of the whole; but such centres are frequently altogether absent, even in small ones, and the larger nodules when examined, often show no appearance of having ever contained any exceptional quantity of organic remains.

Especially observable is the fact that the shape of nodules is found frequently to depend on some external features of the masses of stone in which they occur, such as the occurrence of faults or joints. In a word, the weatherstaining seems to foreshadow the nodule. Besides, there is some reason, too, to think that the coloration accompanying weatherstaining is sometimes accompanied by a physical as well as a chemical difference, such as that between sand and clay, between calcareous and argillaceous stone.

Do not these facts point to an external origin of this spheroidal structure, and suggest the probability that the infiltration of moisture from all points of the surface of a block of stone may, together with some accompanying chemical or molecular action, drive inwards the more soluble constituents of the mass, and thus arrange the whole in concentric layers, and produce in many cases a central nodule?

XXXII.—On the Constituent Minerals of the Granites of Scotland, as compared with those of Donegal. By the Rev. Samuel Haughton, M. D. Dubl., D. C. L. Oxon., Fellow of Trinity College, Dublin.

[Read February, 1870.]

During the last summer (1869) I completed my investigation of the constituent minerals of the Scotch granites, and secured specimens, from the analysis of which I obtained the following results:—

I. *Orthoclase.*

	No. 1.	No. 2.	No. 3.	No. 4.
Silica,	65·40	64·44	64·48	64·48
Alumina,	19·04	18·64	20·00	20·00
Peroxide of iron,	trace	0·80	none	none
Lime,	0·22	0·66	1·01	0·78
Magnesia,	trace	trace	trace	none
Soda,	3·63	2·78	1·72	2·19
Potash,	11·26	12·15	12·81	12·10
Water,	0·20	0·80	0·64	0·08
	99·65	100·22	100·66	99·63

No. 1. Sterling Hill, Peterhead.—Occurs in an eruptive granite, in veins, in well developed reddish-pink opaque crystals encrusted with crystals of albite.

No. 2. Rubislaw, Aberdeen.—Large beautiful reddish-pink opaque crystals, in veins, associated with white mica. The granite at Rubislaw is of metamorphic origin, and different in character from the eruptive granite of Peterhead. No albite has been found in it.

No. 3. Peterculter, Aberdeen.—In metamorphic granite; white, translucent, large crystals.

No. 4. Callernish, extreme west of Lewis.—In metamorphic granite; in large grey crystals, with a slight shade of pink, translucent.

The oxygen ratio of these felspars is as follows:—

	No. 1.	No. 2.	No. 3.	No. 4.
Silica,	33·956	33·456	33·478	33·477
Alumina, &c.,	8·898	8·950	9 348	9·348
Lime,	0·061	0·187	0·286	0·221
Soda,	0·929	0·699	0·440	0·561
Potash,	1·908	2·059	2·171	2·051
	45·752	45·351	45·723	45·658

From this table we find the oxygen ratios—

	No. 1.	No. 2.	No. 3.	No. 4.
Silica,	11·37	11·35	11·55	11·82
Peroxides,	3.06	3·04	3·22	3·30
Protoxides,	1·00	1·00	1·00	1·00

The granites of central and western Scotland are metamorphic rocks, like those of Donegal and Norway, with which they are geologically identical; and truly eruptive granite occurs at a few localities only, as, for example, near Peterhead. The second felspar, associated with orthoclase, in the metamorphic granites, is oligoclase, as in Donegal; while the second felspar associated with orthoclase in the eruptive granites, is albite, as in Mourne, Leinster, and Cornwall. The fact thus indicated by the Scotch granites is completely in accordance with the mode of occurrence of oligoclase and albite in the Irish granites.

II. *Oligoclase.*

	No. 1.	No. 2.
Silica,	62·00	61·88
Alumina,	23·20	24·80
Magnesia,	—	trace
Lime,	4·71	4·93
Soda,	9·20	8·12
Potash,	0·43	0·98
	99·54	100·71

No. 1. This oligoclase occurs in the granite of Craigie Buckler, near Aberdeen; it is white and opaque, and so much resembles cleavelandite in appearance as to have been mistaken for that variety of albite; its analysis proves it to be oligoclase. The crystals do not exhibit striation.

No. 2. From the granite of Rhiconich, in the west of Sutherlandshire; it is greyish white, semitranslucent, in large striated crystals, and resembles the oligoclase of Ytterby, in Sweden.

The oxygen ratios of the oligoclase are as follow:—

	No. 1.	No. 2.
Silica,	32·191	32·128
Alumina,	10·843	11·590
Lime,	1·339	1·400
Soda,	2·360	2·082
Potash,	0·072	0·165
	46·805	47·365

Hence we obtain—

	No. 1.	No. 2.
Silica,	8·54	8·82
Peroxides,	2·88	3·18
Protoxides,	1·00	1·00

These oxygen ratios prove the felspars to be oligoclase.

III. *Albite.*

Silica,	68·00
Alumina,	20·00
Lime,	0·35
Magnesia,	trace.
Soda,	10·88
Potash,	0·68
	99·91

This albite occurs at Stirling Hill, near Peterhead, in eruptive granite, and is found associated with red orthoclase, in veins; it encrusts the large crystals of orthoclase, and is semitranslucent, and generally stained on the surface by peroxide of iron.

Oxygen Ratios.

Silica,	35·306	11·77
Alumina,	9·348	3·11
Lime,	0·099	
Soda,	2·790	1·00
Potash,	0·114	

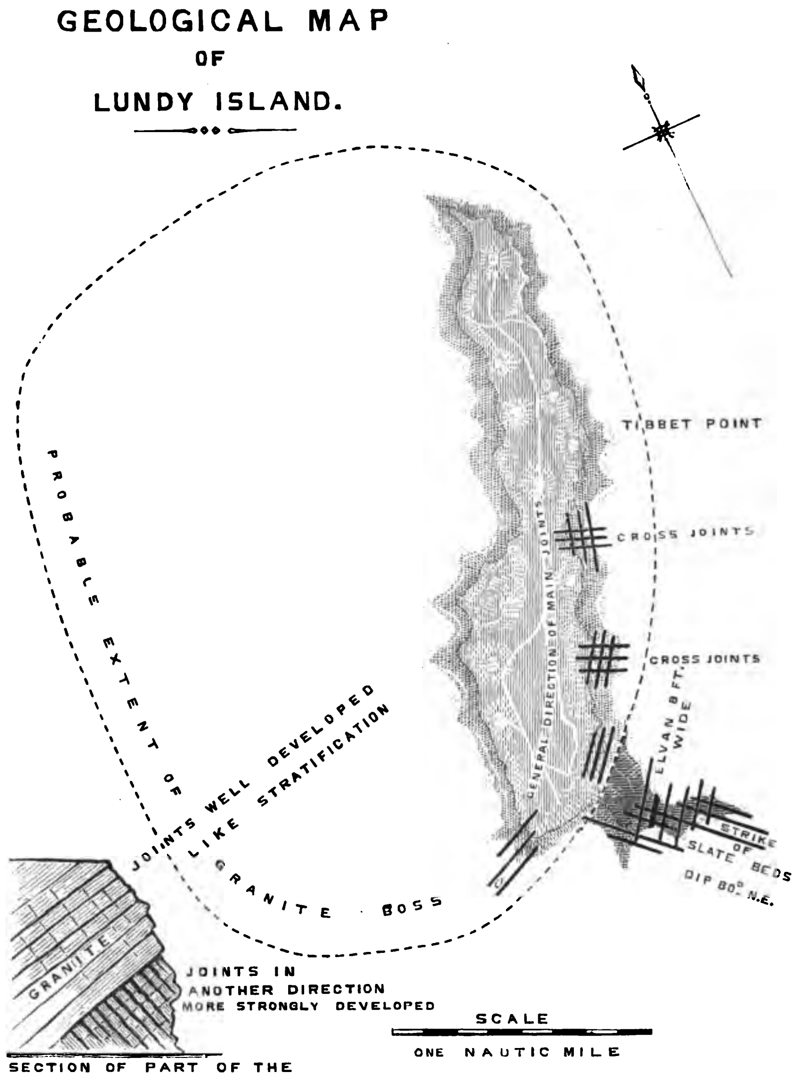
This mineral is evidently a typical albite.

There are two kinds of mica found in the Scotch granites, and both micas resemble very closely the corresponding minerals of the Donegal granites.

IV. *White Mica.*

Silica (SiO_3),	44·40
Fluosilicon (SiF_3),	0·16
Alumina,	37·36
Peroxide of iron,	2·04
Lime,	0·78
Magnesia,	0·57
Soda,	0·93
Potash,	9·87
Protoxide of manganese,	0·24
Water,	1·84
	98·19

The specimen of mica here analysed came from veins in the granite quarry of Rubislaw, near Aberdeen, and occurs in large plates associated with red orthoclase. It was carefully examined for lithia, but no trace of this alkali could be found in it.



SECTION OF PART OF THE
CLIFF NEAR TIBBET POINT.

TO ILLUSTRATE MR. WHITLEY'S LETTER.

The angles of the rhombic plates were 60° and 120° exactly, and the angle between its optic axes was found to be 72° 33′.

The black mica, in large crystals, is very rare, but it seems abundantly disseminated in minute scales through most of the Scotch granites. The following analysis was made on specimens, found near Aberdeen, by Prof. Nichol, and kindly forwarded to me by him, for the purposes of this paper:—

V. *Black Mica.*

ilica, ...	36·50
Alumina, ...	16·50
Peroxide of iron, ...	18·49
Lime, ...	1·11
Magnesia, ...	7·44
Soda, ...	0·92
Potash, ...	8·77
Protoxide of iron, ...	6·76
Protoxide of manganese, . .	1·80
Water, ...	1·60
	99·89

This mica was carefully examined for fluorine, and found not to contain any.

XXXIII.—On the Geology and Structure of the Granites of Lundy Island. By J. Whitley, Esq. (Plate XXI.)

[Read March, 1870.]

Penarth, Truro, February 23rd, 1870.

Sir,—I beg to be permitted to present, through you, to the Royal Geological Society of Ireland, a Geological Map of Lundy Island—which I have forwarded by book-post—being a survey made by myself the past summer.

I have read with much interest your papers on the jointed structure of granite; and you will observe that, at Lundy, the main joints run parallel to the line of junction of the granite and slate, illustrating your opinion that joints "are the necessary consequence of mechanical forces acting on rock masses."

Very truly yours,

Nicholas Whitley,

Hon. Sec. of the Royal Institution of Cornwall.

The Rev. Samuel Haughton, F. R. S.,
Trin. Coll., Dublin.

XXXIV.—On some Corries and their Rock-Basins in Kerry. By Rev. Maxwell Close. (Plate XXII.)

[Read May, 1870.]

The report of the meeting of the British Association, held last year at Exeter, has just been published. It contains a report "On Ice as an agent of Geologic Change," by a Committee, consisting of Professor Torell, Professor Ramsay, and Mr. Bauerman. The Committee contemplate the application of their suggestions for determining the denuding efficacy of ice to glaciated countries where glaciers no longer exist. They propose, among other things, the measurement of moraines; but that method will not be of so much avail in this country, because some geologists, who admit that certain moraines, in Ireland, for instance, have been glacier-formed, contend that the component debris can not have been, and therefore has not been, produced by the glaciers; but that it previously existed in the valleys as drift. The proportion of truth in the latter part of this position, though, I believe, very small, is certainly sufficient to give a handle to objectors, and to invalidate to some extent any argument derived from the size of glacial moraines. Still, there is a way of showing the existence of glacial denudation, and even of assigning, in certain instances, its minimum amount; and that is, by adducing certain physical features which must have been considerably modified by that action, and others which must have been wholly produced thereby. This we shall now do, purposely contenting ourselves with the conquest (if it may be) of but a small portion of the territory of truth, that we may establish ourselves the more securely therein.

The name "*corry*" is now pretty generally applied to those bowl-shaped hollows, partially enclosed by precipices, which often occur on mountain sides. It is, perhaps, best known as employed frequently in the highlands of Scotland; but it is also found in Ireland—e. g. in Galway and Mayo, as Corra-na-binnia, Corrymore, &c. As the word (properly coıpe) signifies *cauldron*, it is very descriptive of the character of the hollows so designated. The French name for this class of physical feature is *cirque*.

The corries in Kerry usually have small lakes lying in their bottoms. These lakes are most frequently dammed in, some perhaps wholly, some partially, by masses of blocks, gravel, and clay; but, in some cases, the basins in which they lie have been entirely hollowed out of the living rock. *Mem.* These cases, however, seem to be much rarer than has been supposed.

The Corry, &c., of Coom Keagh.—We shall now make particular examination of the corry, with its rock-basin, in which lies Lough Keagh,* or, as it is also called, the Pedler's Lake; situated 4⅓ miles, as the crow flies, N. E. of Dingle, a little beyond the highest point of the road over Connor Hill. We select it as being for different reasons, *espe-*

* Named on the Ordnance Maps (but, as it would seem, wrongly) Lough Doon.

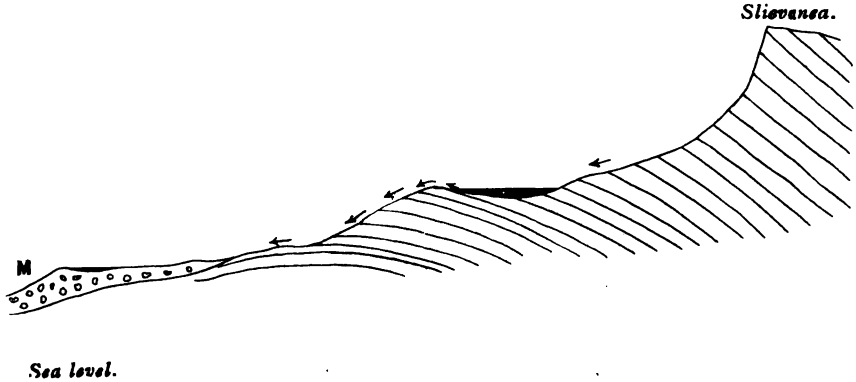
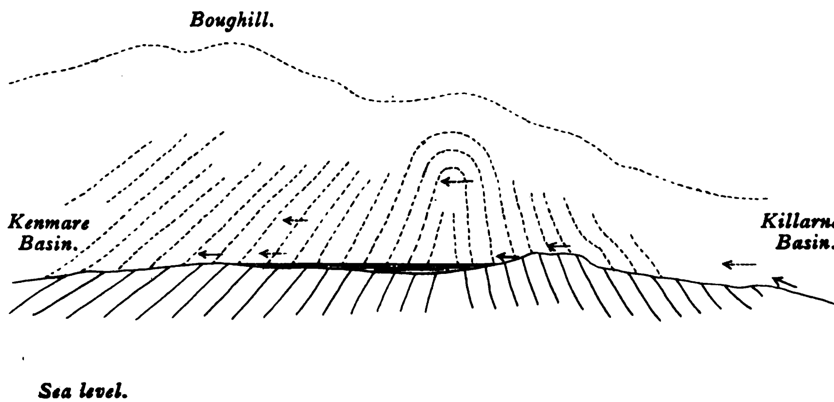
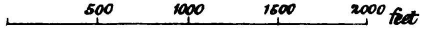


Fig. 1. Section of Coom Keagh. M, Moraine, the lateral portions of which rise on each side of plane of Section nearly to height of L. Keagh. The Arrows mark Rock-scorings.



Fig, 2. Section of Lough Barfinnihy. Boughill Mt., with its indicated stratification, is beyond plane of Section; the dotted Arrows are Rock-scorings on near side of that plane. Horizontal and Vertical Scales equal, and same for both figures.



To illustrate Mr. CLOSE's Paper on Corries in Kerry.

cially on account of its smallness, peculiarly well suited to our present purpose; and notwithstanding its being already the subject of a paper in our Journal. This corry was the first instance in Ireland of a glacier-site, described as such by a geologist (Mr. John Ball), after the visit of Agassiz to this country; and it is somewhat appropriate that its rock-basin should be the first (as far as we know) to be sounded with a distinct glacialistic object in view. We now take for granted, as proved by Mr. Ball, the existence of an ancient glacier in the hollow in question;* and need only refer to the phenomena as they bear upon our present business.

I have sounded the lake on two occasions, by two different methods, with the assistance of Mr. John D. Nagle, of Dingle. The greatest depth obtained was 42 feet 6 inches, in two places; and the gradually decreasing depths around showed that the deepest part, which is situated nearer to the upper than the lower side of the lake, does not lie in any sudden hole or chasm. (Plate XXII., fig. 1).

The edge or brow of the precipitous steep which encloses the back part of Coom Keagh is quite abrupt; and, for a considerable distance, nearly quite level; its altitude above the sea being, there, about 2020 feet. The lough is 1117 feet above the sea. It may be described as of a compact shape, or rudely roundish, with a mean diameter of only 550 feet; its depth, over 42 feet, being proportionally great. Above the head of the lough the rock-scorings run down towards it; at the lower side of the lough they come up out of the water, and run over the rock-barrier confining the lake (this can be seen at a place where the barrier rises 18 or 20 feet above the water), and then down its outer slope, towards the terminal moraine, on which lies the shallow pool called Lough Beirne, 701 feet above the sea. The spoon-shaped moraine (which is largely composed of huge blocks of stone, some of which measure over 30 feet in length) has been carried clear away out of the corry, and far from the rock-barrier, whose mean height above the water of the lough may be estimated at fully 10 feet. The rock is visible all along the barrier, except at the narrow exit of the water of the lake, where it is hidden by some stones; but there are doubtless stones and gravel in the bottom of the lake; so that the depth of the basin is doubtless as much as, and most probably somewhat more than, that given by the soundings.

Formation of the Rock-Basin.—It will be convenient to invert the order of the subjects in the title of this paper; and since some persons still deny that a basin could be hollowed out in its bed by a glacier, it will be necessary to give the reasons which compel the belief that the basin with which we are engaged has been so formed.

When we consider the circumstances of the case, with the object of determining to what operation the rock-basin of Lough Keagh owes

* See his paper in Journ. Geol. Soc., Dublin, vol. iv., p. 151.

its existence, we shall find it, I think, absolutely impossible to come to any other conclusion than that arrived at by Mr. Jukes,* who, in accordance with the views of Professor Ramsay, attributed the hollowing out of such rock-basins in the S. W. of Ireland to glacial action; atmospheric and ordinary marine denudation being out of the question.

It has been suggested (1), that some rock-basins are in areas of special depression; (2), that some, which lie in valleys running into mountain masses, may have resulted from the subsidence of the mountain mass having carried down the floor of the upper part of the valley below the level of its outlet; (3), that some rock-basins have been produced by the faults along which they lie; (4), that some have been excavated by the scour of a stong local current or eddy, when the sea had access to them; (5), that some are, to a great extent, due to the water of their own lakes having removed the rock in a state of solution.† I have never met with any other hypotheses; nor do I think that any really different could be offered.

But in the case of the Lough Keagh rock-basin, which stands as the representative of *its* class, each of the above explanations must be, for various respective reasons, most peremptorily rejected; No. 1, because of the smallness of that basin, which is only about 550 feet in diameter; No. 2, because of its depth, over 42 feet, which is proportionally great, as compared with that of larger rock-basins, and which is only some 350 feet distant from the outlet of the lake;‡ No. 3, because of its smallness and roundish form; no such basin could be produced by any geologically possible faulting; and the extensively exposed rocks show that there has been none; No. 4, because it is quite incredible that such a basin, of so great proportional depth, and formed in such hard and massive rocks, could be the effect of a vortex caused by the tide passing the mouth of the corry when the sea washed into it; and moreover because, owing to the confined situation of Coom Keagh near the head of the closed and deeply recessed Brandon Bay valley, the tide could have had, there, very little motion of translation at all, until the gap of Coum Henry was deeply submerged, and the basin of Lough Keagh as deeply; but when such was the case, if it ever were so, there would not have been enough emergent land in those parts to constitute a barrier sufficient to cause any unusual tidal current at all; and Coom Keagh would have been out of the way of any current. Lastly, No. 5 must be rejected, because the basin is contained in very hard intractable rocks, of a material which is insoluble by rain water (grits of the "Dingle Beds").

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* Explanations to sheets 160, &c., of the Geological Survey Maps, p. 8, *note*.

† Some may have been formed by outbursts of igneous rock damming up valleys, or leaving unfilled places among their irregular and successive accumulations, as in some volcanic craters; but with such, of course, we have now nothing to do.

‡ Professor Ramsay's answer to this explanation, as applied to some of the rock-basins in Switzerland, appears in Phil. Mag. April, 1869, vol. xxix. The most adventurous anti-glacialist would not dare to apply this explanation to the small basin of Lough Keagh; even though it might be available in some cases.

Since it is impossible to suggest any other probable mode of operation, by which that rock-basin may have been formed; and since Coom Keagh presents most striking proofs of its having been the site of a small glacier, which has gone down into the basin, and up again out of it at its lower side, which also had some denuding efficacy, as it has rasped and rounded the rocks in a remarkable manner, and has formed a considerable terminal moraine; and since the basin occurs just at the place where the activity of the glacier, compounded of its pressure and motion, must have been greatest, we are forced to conclude that the glacier has worked out the rock-basin.*

Now, by considering the dimensions, &c., of that basin we shall be able to specify a certain amount of denudation, which, at the very least, this agent has accomplished. We see, then, at once, in the first place, that a depth of more than 42 feet of a very hard and massive rock has been removed by the action of the necessarily small glacier which occupied the corry. But we may go farther than this. Once it is admitted that it is *by the glacier* that this has been done, there is no longer any reason for referring the depths in the rock-basin to the level of the outlet of the water of the lough. We are clearly entitled to add to the greatest depth of the water the mean height, say 10 feet, of the rock-barrier confining it. It is evidently owing to mere accident, and it is a quite unimportant circumstance, that the water is not deeper than it is by that amount. The rock-basin, regard being had to the agent by which it has been formed, is equivalent to one 52 feet in depth; the glacier must have removed that thickness of rock. But we must go farther still. The excavation of a basin by a glacier is but a *differential* effect; while the glacier was partly grinding, partly ripping away, and extruding 52 feet of rock from the basin of Lough Keagh, it could not have been passing harmlessly over what is now the rock-barrier enclosing that basin; supposing it to have removed only 10 feet of rock from above that barrier (which seems to be a very moderate estimate), it must have removed upwards of 60 feet from it from the middle part of the basin.

But once we realize to ourselves that the glacier has done so much, there is no difficulty whatever in believing that it may have done more, if only there be some reason for supposing so. Now it is not probable that the glacier, when first formed, found a ready made perfectly level floor on which to commence operations within the corry, at the elevation of 10 feet above the mean crest of the rock barrier; if such ever existed, it was, most probably, formed by the glacier itself, from a pre-existing slope which stood above it.†

* It is very unfortunate that the action by which a glacier may work out a rock-basin should be so often described by glacialists as "ploughing," "gouging," &c. Though these words are, of course, used metaphorically, they are sometimes taken literally by opponents; and so have become the occasion for needless objection.

† It should be borne in mind that we are not entirely dependent on the glacier which *succeeded* the general ice-covering of the country. It is reasonable to conclude that, as

Formation of the Corry itself.—It is generally more or less evident, sometimes strikingly so, that these hollows, as they now appear, are of a different order from the other shapes of the mountains on which they occur. They have been wrought upon the pre-existing general contour of the mountain. One is often tempted to think that a corry is a thing altogether *sui generis*. Still it may be but an instance of a wider class of physical features, the style of which is due, partly to its being at a particular stage of formation, and partly to the concurrence of certain favourable circumstances. It is clear that a well-formed corry, such as Coom Keagh, need not be dependent on any local disturbance, of any kind, in the rocks; neither is it immediately dependent on the lie and position of the beds. But, from its so frequent occurrence (as far as my experience, at least, goes), it is evidently a favourable, though not an indispensable condition for the production of a well-formed corry, that the rock beds, out of which it has been hollowed, should be tolerably horizontal; or, if they have much dip, that it should be into the mountain, or towards the head of the cavity; the reason probably being that those are the positions in which the rocks have greatest stability, and consequently greatest capability of forming a precipice, when exposed to suitable denuding action.

Coom Keagh has been, as we have seen, undoubtedly affected by the operation of the glacier it has contained, inasmuch as its bottom has been hollowed into a rock-basin by that glacier. The following considerations conspire to induce the belief that ice-action has been largely concerned in bringing the corry to its present condition.

(1). If the glacier have formed the rock-basin, it must have considerably modified other parts of the recess containing that basin. Mr. D. Mackintosh has remarked to me, what is very evident in the case of Lough Keagh, that the rock-basin is often simply an integral part of the corry, and not a feature which has been subsequently formed in its bottom.

(2). Again, according to Professor Ramsay, the corry is eminently characteristic of all glacier countries past or present.*

(3). Again, as a general, though not invariable rule in this country, the hollows in question affect the highest parts of mountains, where the glacial conditions were most favourable, and where they must have endured longest.

(4). Again, as was long ago noticed by the Rev. Cæsar Otway,† the great majority of them face in a northerly, to which we may add, and easterly, direction. This is very decidedly so in Wicklow, in

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corry glaciers existed during the decline of the glacial period, so they must have existed during its earlier stages, before it had reached its climax. As a general rule, no *distinguishable* evidence of the older local glaciers could now be preserved; but a probable exception to this seems to be afforded by Lough Barfinnihy mentioned below.

* "On the glacial origin of certain Lake Basins." Quart. Journ. Geol. Soc. London, vol. xviii., 1862, p. 186.

† "Tour in Connaught."

Mayo, and (though with more exceptions) in Kerry. It was very interesting to me to find that Dr. Busteed, of Castle Gregory, had independently noticed this circumstance in the Dingle promontory. Mr. D. Mackintosh informs me (see also his work on "The Scenery of England and Wales," &c., p. 190) that in the Lake district of England, and in Wales, such hollows generally face in a northerly or easterly direction. The usual north-eastward tendency of Irish corries is an unquestionable fact, which deserves special attention. It obtains in spite of the general trend of the mountain ridges in Ireland, which, being N. E. and S. W., might be expected to give greater opportunity for corries turned towards N. W. or S. E. This is strikingly instanced by the deep corries on the north-westward side of the Maum Thomoish ridge, in Mayo, where we might anticipate finding corries looking north-westward unless there were some particular reason against it. (*Mem.* The lakes in these are dammed-in by enormous moraines.) It is evident that, of all mountain hollows in countries such as ours, those which looked somewhat northward* or eastward would have had, *cæteris paribus*, the best chance of containing the largest and most enduring glaciers, and must, therefore, have been the most modified by glacial action. The south-westerly winds which now prevail in this country, being the returning trade-winds, doubtless prevailed, likewise, during the glacial period; and if so, hollows turned north-eastwards would generally catch the largest amount of drifting snow. They would also be the most protected from that wind (the least cold, though the greatest snow-bringer and drifter) when in its less ungenial moods; and they would be nearly the most inaccessible to the direct action of the sun.† Coom Keagh itself, which looks N. W., affords evidence, from the course of the rock-scorings, that the snow was more deeply heaped in its south-west part.

(5). Again, the *cauldron*-like shape of the corry is just what we should expect would be superinduced by an agent formed, moving, and acting as a small glacier; and unlike what we should expect (except under peculiar circumstances) from marine or atmospheric denudation, or a combination of both.

As to the atmosphere: when it is unassisted by its product, running water (which in the present case is out of the question), though it may make rugged outlines, and carve ridges into serrated edges, and give rise to escarpments along the outcrop of a series of harder rocks, it

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* The reverse obtains in the case of the Himalayas; but the reason of this is well known. An interesting confirmation of the argument above is afforded by the fact that the exceptional instances so frequently occur on the highest hills, which were less dependent than others upon auxiliary conditions for the production and preservation of their glaciers.

† We seem to have an illustration of this near Sneem, in Kerry. Four miles northward of that place are three contiguous corries, all having their proper names. Two of these, Coomassig and Coomnacronia, look southward. The third is turned towards E. by N.; it is the deepest, and its distinctive name is Coomeenthna, the *snow-coom.*

does not seem to have the capability of making a precipice (properly so called) out of a homogeneous rock-mass. At least in these countries it is now engaged in trying to soften away precipices, by eroding more rapidly the upper exposed parts, where it has greater power. The effect is heightened by, but not entirely dependent upon, the fact that it covers and protects from itself the foot of a precipice by the *debris* which it loosens from the upper part.

As to the sea: though it has the power of making precipices, being engaged at the present day in so doing, several considerations conspire to make it very improbable, in some cases, that the original hollows were due to this agency.

(1). The sea does not seem to be now producing *such* features on the south-west coast of Ireland. There is, indeed, a fine corry called Sause, near Brandon Head, in the Dingle promontory, which descends into the present sea; but there is nothing to compel us to believe that it has been produced thereby.*

(2). The floors of immediately neighbouring corries will often be of very different elevations, and without there being any apparent terraces on the open mountain sides, which in any way correspond with the corry floors. For instance, near the head of the great Brandon Bay valley there are six corries, of which Coom Keagh is one, all on the same range of mountain side. The first contains Lough Adoon (moraine-dammed), whose water is 391 feet above the sea; the next contains Lough Camclaun (moraine-dammed), 774 feet; the rock-floor of the next carries two little pools near its upper part, 1289 feet; the rock-floor of the next, Coom Keagh, we shall set down at 1127 feet; the next, Coomeenoughter, contains a lake (moraine-dammed), 746 feet; the next, containing Lough Duff, slopes down to the bottom of the valley, say 400 feet above the sea. We purposely omit Barnanageehy and those on the Brandon range, because their positions and aspects

* This remarkable hollow is probably being modified by the present sea. It is a deeply-recessed, regularly-formed corry, with precipitous sides. Its brim at one place (Carrig-a-tormon), not the very highest, is 1320 feet above the sea, at the horizontal distance of exactly ¼th mile from the shore line. Here and there deep fissures run along above the brim, and parallel to it, and in some places a considerable distance back from it. Sometimes there are two parallel fissures, one behind the other, and, if I remember right, at one place three. These are not properly land-slips, as they have not given rise to any steps or terraces running along them. (*Mem.* There is a land-slip, not far off, on the sea side of Knocknabreestee). They are rather to be compared to the fissures caused in a building by the settlement of part of the foundation. The precipice has toppled forward by a few feet, and the rocks have taken a new bearing. All this may undoubtedly be due to the undermining action of the sea at its present level, although the sea is now fenced off by a talus, on which are the remains of a house and some enclosed patches of lately cultivated ground. The sea must have had some effect on this corry (it is now escarping the talus), as it has had on the shore at each side. But if that coast were now to be upheaved, we should have a raised beach or terrace in the bottom of the corry, and running away from its entrance on both sides, which would make a difference between this corry and those mentioned in the text, *that difference being due to the modifying action of the sea.*

are dissimilar. The same thing is illustrated by the corries at the head of Glenbeh in Kerry (and also by those on the Ballycroy side of the Maum Thomoish mountains in Mayo).

(3). Corries have, as far as I know, no perceptible preference for places which were most exposed to the action of the sea. Many of these hollows are in such sheltered positions, that when the sea washed into them it could not have exercised any denuding power on them worth considering. Of this many instances might be given; one of the most striking, perhaps, is the well-formed corry containing Lough-na-m-Brack Dearg, and opening at right angles into the narrow and deeply withdrawn valley of the Coomhola river near its head. The level of the small (moraine-dammed) lough is about 280 feet lower than the *col* at the upper end of the Coomhola valley; therefore the corry could not have been hollowed by the sea when the latter was deep enough to flow through the valley. We may also mention here the deep corry in the side of Maol, which contains Lough Duff, the head of the River Laune, near Killarney.

(4.) Corries, properly so called, on different sides of a mountain, have a decided disinclination to encroach much upon one another. When they do interfere, and so give rise to the narrow edges, or *arêtes*, by which they are sometimes separated, it is but to a small extent. The ridges which divide them usually have a positive substantive character. They are very seldom (though they are sometimes) of secondary rank, as to genesis among the mountain shapes, which they would be, if they were but remnants left by the intersection of two independently produced spheroidal hollows. They seem to have been in some way concerned in the formation of the hollows, which, by reaction, have sometimes modified and more sharply defined themselves. Of this various illustrations could be given.

The following considerations, in addition to those mentioned above in favour of glacial action, tell against both the atmospheric and the marine origin of corries as they now appear.

Corries have a decided preference (in this country, at least) for the higher mountains; this partially (though not completely) explains the tendency they have to congregate together. The prevalence of deep hollows, often separated by narrow radiating ridges, on our higher hills, gives to these a character specifically distinct from that of hills a thousand feet or so in height. Now, if corries have been produced by ordinary atmospheric, or by marine, denudation, or by a combination of both, there seems to be no sufficient reason why they should not be as common on the lower as on the higher hills. This is a greater difficulty for the marine than for the atmospheric denudationists.

Again, there is often no apparent reason why the ordinary atmospheric, or the marine, agencies should work out an abrupt punch-bowl at one spot, and, as is often the case, leave the mountain side, on either hand, with a swelling, unbroken contour. It is often quite evident that a corry, as it now stands, is the result of some action which has been working with peculiar intensity at that place; and it is also fre-

quently impossible to explain why the sea or the atmosphere should have done so. But if there were a pre-existing hollow of some kind at the place to begin with, there is a very intelligible reason why the ice should collect therein in much greater quantity, and work therein with greater force than elsewhere.* There must have been this pre-existing hollow to determine the formation of a sufficiently active local glacier at the spot; but the developing corry was ever assisting more and more in its own development. While some of the original hollows may have been, and probably were, the work of Neptunian agency, others cannot have been so. But, however this may be, the considerations now adduced point to the conclusion that the characteristic style of the corries, as they now stand, was given to them "sub Jove—*frigido*." This indeed only indicates the fact that there has been considerable glacial denudation; it does not enable us to estimate the amount of it.

Some other Corry Rock-Basins.—We may just mention some other corries containing rock basins. Coomcallee, a very bold characteristic one, slightly smaller than Coom Keagh, is four miles W. by N. of Sneem, on the north side of Kenmare River, or Bay. Its lough (1024 feet above the sea) is very slightly larger than Lough Keagh, and 51 feet deep in the deepest part, which is not situated in any abrupt cavity; but the water is partially dammed in by a well-defined, latero-terminal moraine. I believe, however, that that moraine stands within the rock-basin of the corry, and that if it (the moraine) were removed, and the narrow passage outside it through the rock, by which the stream escapes, filled up, the lake would have nearly the same depth as at present. The glaciation of the rocks is very striking; though the striations have not been well preserved;—on the south *side* of the lake they rise slantingly out of the water. I believe that the basin-forming action has gone farther here than at Coom Keagh; though the presence of the moraine renders this somewhat doubtful.

The small upper lake at Coomassig, also near Sneem, is of about the same extent as the last; it lies in a shallow rock-basin, 1500 feet above the sea, in the upper part of a two-storied corry. The basin has some particularly fine rock-rounding and grooving beside it; it is well exposed, the moraine of the glacier having been carried clear away down to the lower storey of the corry, where it dams in the much larger Eagle's Lough, 460 feet below.

Coomeenadillure, at the head of the valley of the Cloonee Lakes, on the south side of Kenmare River, is a deep, well-enclosed corry, larger

* A considerable proportion of the mass of a small corry glacier must have been composed of snow *drifted* into the hollow; we are told that this is the case with the present secondary glaciers of Switzerland. We may here observe that, as is evident, the amount of additional drifted snow must be greater proportionally in a smaller than in a larger catchment hollow. This perhaps will *partly* explain the fact noted by Professor Ramsay, and often illustrated in Ireland, that small glacier hollows generally have proportionally large moraines.

than those already mentioned. Its lake is partially dammed-in by a magnificent terminal moraine; but if the water be over thiry-five feet in depth (and it must be, I believe, much more), the lower part of the lake is in a rock-basin. The elevated hollow, appropriately named Coomeenoughter, between Carrane Tual and Ben Keeragh, contains a little tarn, 2338 feet above the sea. This tarn is evidently, as seen from the summit of Carrane Tual, in a rock-basin; but it is not easy to climb down to it. The smallness of the basin, however, prevents its being of much significance. Lough Erhogh, in the upper end of Glennagoppal, near Killarney, is partially in a rock-basin. The testimony of all these is, in a general way, confirmatory of that of Croom Keagh and its rock-basin; but we cannot draw therefrom such definite conclusions.

The supposed mechanical difficulty disappears on a little consideration. Assuming the pressure at the bottom of a glacier to be always insufficient to melt or soften the ice too much (as must be the case with the smaller glaciers), and assuming the *moraine du fond* to be sufficiently deep or thick to allow of its being somewhat drawn out without losing its continuity,* then the erosive power of any part of a glacier is nearly equal to the product of its pressure and its rate of movement. The former of these factors vanishes at the head, the latter at the foot of the glacier; and the product must be cypher at both those places, and a maximum at some intermediate point.† At some place near that point, the exact determination of which place will partly depend on the varying character of the rocky bed of the glacier, the erosion must be a maximum, and the glacier must *tend* to produce a basin there; and it *will* do so, if time enough be given, and if there be no mechanical impossibility in the operation; but there is none. A glacier is not only a *river* of ice, it is at the same time a river of *ice;* and, therefore, although in some respects it will comport itself very similarly to, yet in others it will behave very differently from, a river of water. The frequently-made assertion that the upper part of a glacier must pass over that part contained in a basin in the bed of the glacier would involve that the *shear* of the ice all over the area of the uppermost horizontal section of the basin should be less than the friction and other resistance between the surface of the basin and the bottom of the glacier; whereas, owing to the peculiar nature of ice, it is very much greater, provided that the basin be not too deep proportionally, and that its bottom be a tolerably ordinary rock surface. All rock-basins, that I know of, are of moderate proportional depth (except some of the *riesentöpfe,* which do not bear on the present question); and it is evident that any new surface which a

* The omission of this condition vitiates the argument in a paper "On Rock Basins," in Phil. Mag., vol. xxix., 1865, p. 526; and another oversight vitiates the application of the argument when used to disprove the possibility of basins being hollowed out by glaciers.

† If the glacier be a long one, there may be also subordinate "relative maxima" in other places, which may likewise give rise to basins.

glacier could work on its rocky bed will be more favourable to the passage of the glacier than an ordinary rock surface. The bottom part of a glacier can, therefore, move into, and again out of, a not too deep basin in its bed; and consequently must have some denuding efficacy in that basin.

Lough Barfinnihy.—We must not omit to mention a very remarkable rock-basin which does not *obviously* corroborate the testimony of those already mentioned, and which, therefore, might be thought by some to afford a sort of negative disproof of the foregoing argument. Lough Barfinnihy, which is situated nearly a mile westward of Windy Gap, the highest point of the road between Killarney and Kenmare, lies, at the height of 827 feet above the sea, on the watershed,* in a gap on the mountain ridge which separates the Killarney and the Kenmare hydrographical basins. (Plate XXII., fig. 2.)

This lake is contained in a well-displayed rock-basin, whose length is 495 and mean width 360 yards, and whose greatest depth, not contained in any sudden chasm, is at least 54 feet. On its westerly side, the slightly concave, rocky, precipitous steep of Boughil rises 1236 feet above it. The rock-basin and the precipice look as if they had the same relation as in Coom Keagh; yet there is no trace of a local glacier in the shape of either rock striation or moraine; on the contrary, the rocks around have been well ground and scored by a flow of the *general* ice system, which has streamed through the gap from the Killarney to the Kenmare basin. It is absolutely impossible that the basin could be the work either of the sea or of the atmosphere; and none of the explanations above mentioned of such physical features is here at all applicable. How, then, was the basin excavated? Possibly by the said ice stream, which has left its numerous traces on the rocks around. But this seems rather improbable; it would be more likely had the basin been turned the other way. Since, as we have said, the basin and the precipice look as if they had the same connexion as in Coom Keagh, we seem driven to suppose that the rock-basin was worked out by a local glacier, which existed during the advance of the glacial period, before the development of the universal ice system. Such local glaciers must have been formed in suitable places, before as well as after the time of the general glaciation. The sharp, anticlinal fold in the beds would cause a weakness of the rocks just where a glacier, collected under the slightly hollow precipice of Boughil, would have the greatest tendency to work out a basin, and this, doubtless, has promoted the formation of that basin. If the bed of Lough Barfinnihy have been thus excavated, it is of very special interest to the glacialist, as it is the only *distinguishable* token with which I am acquainted of the existence of an earlier local glacier. At any rate, we are compelled to conclude that a depth of at least 54 feet of O. R. S. grits and slates has been removed from the spot by glacial

* Its overflow, at its southern end, forms the Finnihy river, which runs down to Kenmare. Only 73 yards from its northern end, a small stream rises, and flows down into Coomalomena, part of the Killarney basin.

action. How much more we cannot say; but that it must have been more, the considerations adduced above, in the case of Lough Keagh, require us to believe.

In conclusion—returning to Coom Keagh. We have attempted to indicate the minimum amount of abrasion (not to be despised, however) effected at a certain place by the most active portion of a very small extinct local glacier. That same glacier exercised no denuding power at its lower end, since it has there, to some extent, mounted upon its own terminal moraine, as existing glaciers often do. At that part its motion was sluggish, and its pressure probably greatly diminished; it had, besides, more work to do there than elsewhere in the sweeping along of the accumulating underlying detritus—consequently its erosive effect on the rock there became *nil*. We may here observe that this removes the force of an objection, sometimes urged against the power of a glacier to form a basin in its bed, drawn from the fact that when existing Swiss glaciers retreat, in consequence of some temporary change in the climate, they do not appear to have been engaged in hollowing basins in the freshly exposed parts of their beds. The most active is a more fairly representative part of a glacier (necessary allowance being, of course, made) than the least active part. The just mentioned fact militates strongly against the supposition (which is, moreover, *à priori*, untenable) that the obstruction of the terminal moraine is conducive to the formation of a basin just above it.* Some who may not believe this, are yet inclined to suppose, when they see a moraine-dammed lake in a mountain hollow, that the underneath part of the lake is most probably in a rock-basin. Such, no doubt, is sometimes the case, as in Coomeenadillure, above mentioned; but, when it is so, the moraine has been formed at a later time than the basin; and if there be any immediate connexion between them, it is that the latter has conduced to the formation of the former, as probably happened in Coomcallee, where the latero-terminal moraine stands a little within the rock-basin.

We cannot draw from the foregoing any conclusions as to the extent of the denudation effected by the *universal* glacier; it must have been very different in different places—greater on hills across which the ice moved, than on the low grounds; but on the whole very much less, in proportion, than that of a local glacier, yet still enough to modify considerably, in favourable places, the effects of the older atmospheric and marine operations; which circumstance has, of course, to be borne in mind in the endeavour to solve the problem of the shaping of the surface of the ground by denuding agencies.

NOTE.—Lough Barfinnihy is exceedingly interesting, not only intrinsically on account of its singular position, and what it seems to intimate, as mentioned above, but also on account of its relations with Lough Fadda, nearly three miles due west of it. The two together

* "Quarterly Journal of the Geological Society of London," vol. xxi., 1865, p. 131.

form a peculiar study (not without difficulty) for the glacialist; whilst, both separately and conjointly, they can only excite perplexity and despair in the non-glacialist. The similarity, as to physical *geography*, between these two lakes is very remarkable. Both lie in gaps on the mountain watershed between the Killarney and the Kenmare hydrographical basins; both drain into the latter. The western, but not the eastern, side of each gap is a slightly concave, rocky, precipitous, steep. The scale of these physical features is much the same. Lough Barfinnihy is 827 feet in elevation, and the precipice of Boughil rises 1236 feet above it. Lough Fadda is 983 feet in elevation, and the precipice of Knocklomena rises 1114 feet above it. Yet the dissimilarity, as to physical *geology*, between the two is equally remarkable. Lough Barfinnihy is in a rock-basin, which has no traces of any local glaciation about it, though there is ample proof that a flow of the general ice system has streamed through the gap, across the basin, from the Killarney side. On the contrary, Lough Fadda (i.e. the long lake, its length runs through its gap, or at right angles to the watershed line), is dammed in at both ends by the extremities of a great moraine, which runs along its eastern side. This has unquestionably been formed by a local glacier from the precipice on the other side of the lake; it could not by any possibility have been either formed or deposited where it now is by the sea or by atmospheric agencies. It is heaped up against the eastern side of the gap to a height of 140 feet above the water of the lake. Its crest stands out clear, so that there is a short slope thence to the hill side on one hand, and a long slope down to the water on the other. There are a great many large blocks of rock scattered over it; one huge mass, weighing perhaps 200 tons, was evidently a single block originally, though now split into several portions. The size of this moraine is very surprising; but the precipice of Kocknomena would be admirably adapted for collecting an enormous quantity of snow drifting from the *south-westward*. But why did not the precipice of Boughil, so similar as to shape, scale, elevation above the sea, and azimuthal *aspect*, collect its own later glacier? This is, at first sight, a difficulty; but we may answer—For two conspiring reasons—first, the Barfinnihy gap was nearer than the other to the (complex) centre of the great glacial dispersion; and, secondly, it is the lower of the two; consequently it may well have been occupied by an ice flow from the direction of the Reeks all the time that the Lake Fadda gap was filled by a local glacier from the precipice of Knocklomena.

XXXV.—Notes on Calamoichthys Calabaricus (J. A. Smith). By Ramsay H. Traquair, M.D.; Professor of Zoology in the Royal College of Science, Dublin.

[Read June 8, 1870.]

Having recently obtained four very fine male specimens of Calamoichthys, I am enabled to supplement to some extent the original description of this remarkable West African ganoid, as given by Dr. J. A. Smith, the founder of the genus.* It will also be seen that my decription differs from his in certain particulars.

Three of these specimens are larger than any I have hitherto seen; one, which measures 15 inches in length, being fully 2½ inches longer than the largest example mentioned by Dr. Smith. We have no certain information as to how large this fish may actually grow; according to the Rev. Mr. Robb, as quoted by Dr. Smith, it attains a "considerable size," an expression which is, unfortunately, rather vague.

Head. The head, measured from the tip of the snout to the posterior-superior angle of the operculum, is contained in the male, about fourteen, and in the female about thirteen times in the entire length of the body. The cranial bones or plates, which have ganoid external surfaces, are the parietals, frontals, nasals, the opercular, and jugular plates, the so-called preoperculum, the supra-temporals, and the "intercalary" spiracular, prespiracular, and postspiracular ossicles. The supra-temporal bones or plates are, as in Polypterus, six in number, forming a transverse chain across the back of the head behind the parietal bones, and must not be confounded either with the supra-occipital, or with the epiotic bones of the head of Teleostei.†

The spiracular valve is very regularly composed of two ossicles; only in one small female specimen have I seen a third and very small additional one, intercalated between the normal pair at the outer or attached margin of the valve. The small ganoid plates, in front of and behind the spiracle, are not quite so constant in number, and often they differ in that respect on the two sides of the head in the same specimen; usually, however, there are four or five prespiracular, and four or five postspiracular ossicles on each side.

The external sculpturing of these ganoid cranial plates is in the form of fine rounded elevated ridges with intervening furrows, frequently interrupted, and also blending with each other, mostly arranged concentrically towards the margins of the plate, but passing towards the centre into an irregular vermicular tuberculation. In dried specimens, numerous fine punctures analogous to those of the scales, and communicating with the Haversian system of the interior, may be

* "Description of Calamoichthys, a New Genus of Ganoid Fish." By Dr. J. Alexander Smith. Trans. Royal Soc., Edin., 1866.

† See Parker's "Monograph of the Shoulder Girdle and Sternum," p. 19.

observed in the furrows and depressions of the sculptured surface, The tuberculated portion is not in all the plates central; in the case of the frontal bones it is situated on the inner margin of each, so that it is the surface of the two plates taken together, which constitutes an area ornamented by the general pattern just described. Also, the concentric arrangement of striæ is hardly visible on the small supra-temporal and intercalary ossicles (spiracular, &c.), their surfaces exhibiting scarcely anything but irregular tubercles.

The rest of the head is covered by soft skin; the lips are fleshy, and at the angle of the mouth is seen a well-marked triangular labial cartilage as in Polypterus.

The following elements of the shoulder girdle have ganoid surfaces sculptured in a manner similar to the cranial plates—post-temporal, supraclavicular, postclavicular, clavicular, and preclavicular. The markings on the clavicular and preclavicular bones are, however, very feeble.

Scales of the Body. These are arranged in zones or bands, passing obliquely downwards and backwards over the sides of the body. Counting from the supra-temporal and post-temporal bones at the back of the head, there are 107 to 110 of these zones, and consequently the same number of scales of the lateral line; if we commence, however, on the ventral aspect from behind the preclavicular plates, we find nine to ten additional segments of zones, which are, of course, imperfect above. These scales are arranged for the most part with the greatest regularity, although deviations are occasionally met with, as, for instance, the bifurcation of one of the oblique rows, or the intercalation of a small odd scale between two contiguous bands. A row of peculiar, somewhat rectangular-shaped scales, borders, on each side, the origin of the anal fin and the small cloacal slit lying immediately in front; above this row there are some scales of small size and irregular form.

In front of the first dorsal finlet each of the oblique zones consists of an azygos scale above and below, and fourteen or fifteen intermediate lateral scales on each side; but these numbers are not very constant—in one zone, for instance, I found fourteen intermediate scales on one side, and sixteen on the other. The scales on the flank are of a rhomboidal shape, and are very uniform in size throughout the length of the body, as far as the caudal region. One taken from the middle of a band, between the head and the first dorsal finlet, in the specimen 15 inches long, measures $\frac{3}{10}$ inch in its longest oblique diameter, that is from its anterior-superior to its posterior-inferior angle. The posterior margin is straight, and finely denticulated; the lower, convex; the anterior, overlapped by the scale in front, is concave, and runs out above into a prominent blunt process, directed upwards and forwards; while from the upper margin, which is also concave, there projects a sharp spine for articulation with the lower surface of the scale next above, by which scale this margin is also very slightly overlapped. The manner of articulation is seen clearly on examining the attached surface of the scale. Here, from the bevelled-off, convex lower margin of the scale,

a pointed depression passes upwards, lodging the spine of the scale below. The anterior margin of the articular pit is thickened and prominent, and passes upwards as a slightly raised bar, which terminates finally in the spine of the upper border of the scale. The ganoid surface occupies nearly the whole of the external aspect of the scale; its margins are straight in front and behind, concave above and convex below. With the naked eye, hardly any further sculpturing is perceptible than an indication of concentric lines. When magnified, the shining surface is seen to be ornamented by numerous pits or punctures, arranged, towards the posterior and lower margins of the scale, in more or less concentric and also radiating lines, but becoming irregularly distributed towards the centre and superior-anterior angle. From each of these punctures a minute, soft papilla, demonstrable by careful examination of the moist scale, arises as in Polypterus. Between the concentric lines of punctures, slight elevated concentric ridges, more or less prominent in different individuals, are also to be distinguished.

The median scales of the back and belly are peculiar in form; those of the dorsal series are oval, and are armed with three sharp teeth or spines in front, of which the median is the most prominent, and is overlapped by the median scale in front, while each of the two lateral teeth is covered by the first of the lateral scales of the series next in advance. Dr. Smith figures and describes only two of these spines, but I have invariably found them to be three in number. The deep surface of the scale shows a median ridge bifurcating posteriorly, each branch terminating in a pointed pit, into which is fitted the spine of the superior margin of the first lateral scale on each side, belonging to the same zone.

Towards the belly the scales become smaller and narrower; the median ventral scale is rhomboidal in shape, with a long anteriorly directed spine, overlapped by the scale next in advance. There are also two small lateral teeth, one passing outwards on each side from the base of the central one, to articulate with the lowest lateral scale of the series.

The median scales of the belly are continued back as far as the vent, but those of the back cease at the first or second band in front of the first dorsal finlet, and are thence backwards replaced by a duplex series. The supporting spine of each dorsal finlet is articulated in a deep notch cut out in the contiguous posterior margins of the two-paired scales immediately in front of it; while the two, sometimes the three, pairs of scales next behind form a shallow groove, into which the spine and finlet are folded down when not erected.

The scales agree in their internal microscopic structure in every essential respect with those of Polypterus. They are composed of an osseous substance, with numerous bone-corpuscles or lacunæ, and beautifully ramifying canaliculi. Numerous vascular canals pierce the deep surface of the scale, and enter a beautiful network of Haversian tubes lying closely below the surface. From this network small branches are given off, which pass perpendicularly towards the free aspect of the scale,

and terminate one in each of the punctures which ornament the surfaces, the contained blood-vessel apparently ending blindly in the soft papilla connected therewith. A considerable amount of pigment is contained in the Haversian canals of the scales of the darker regions of the body, and to which the colour of the fish is due. The ganoid plates of the head display a microscopic structure, essentially similar to that of the scales of the body.

Lateral Line.—The lateral line consists of a row of pores on each side of the body, one on each of the longitudinal series of scales, which are thus distinguished as the scales of the lateral line. In the front of the body the number of scales between the median scale of the back and the lateral line is usually four, though sometimes five. The pores do not succeed each other with perfect regularity, sometimes one or more scales being, as it were, missed over. Besides these, scattered pores are seen on many of the mesial scales of the back, or on scales between those and the regular lateral series; those sometimes form in the hinder region of the body an indication of a second or superior lateral line. There is neither in Calamoichthys nor in Polypterus any lateral *canal*, the pores in question being only oblique depressions, or pits, on the surface of the scales; but there is developed on the head a regular slime-canal system traversing the superficial bones, and the plan of whose ramifications agrees very closely with that in Teleostean fishes. Numerous symmetrically placed pores connect this cephalic canal system with the external surface.

Pectoral Fins.—The pedicle of the pectoral fin is clothed with small rhomboidal scales on its external aspect, except on a naked semilunar space at the origin of the fin-rays; on its inner aspect the pedicle is naked, except along its upper and lower margins, around which the scaly covering of the outer surface is to some extent reflected.

Dr. Smith gives seventeen as the number of rays in the pectoral fin of his largest male specimen of 12½ inches in length. This number I have found repeated in a male of 11¼ inches; but in specimens larger than that I have found the number to increase with the size of the fish. In a specimen 14 inches long there were 19 rays; and in one of 14½ inches 20 rays in each pectoral fin; but in my largest male of 15 inches, I ascertained, after very careful counting, 21 rays in the fin of the right, and 22 in that of the left side. The rays show numerous transverse joints, and, except the minute ones at the upper and lower margins of the fin, bifurcate once. They are soft, that is to say, destitute of ganoid surface, and covered with a distinct stratum of soft skin; and I have never seen any trace of the "single rows of very minute ganoid scales" which Dr. Smith has described as covering them.*

Anal Fin.—The anal fin, following immediately on the vent, has a structure essentially similar to that in Polypterus. On the anterior margin of its origin is a rhomboidal patch of small scales, folded

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* *Op. cit.*, p. 467.

so as to look triangular on each side. The scales on this patch are minute internally, but those forming the margins are larger. The number of rays is fourteen; of these the five hindermost are minute and soft, while the other nine are hard and ganoid on their outer surfaces, except at their extreme terminations. These ganoid rays show very numerous, short transverse joints, and their lateral moieties overlap each other regularly from before backwards.

Caudal Fin.—The rays of this fin are all hard and ganoid, with numerous transverse articulations and beautifully striated surfaces, and bifurcate once or twice, save a small and variable number on each margin, which are simple. Thirteen is their number in all the specimens before me.

Dorsal finlets.—These vary in number, the smallest number hitherto recorded being nine, and the largest eleven; but there are twelve in my large male of fifteen inches. The last dorsal finlet is almost invariably connected by its membrane with the caudal fin; sometimes its predecessor is also similarly joined with it, as in the large specimen alluded to. Each finlet consists of a flattened spine, ganoid and sculptured on its anterior surface, and at its extremity bifurcating into two sharp points, which are not always of equal length. This spine gives origin, on its posterior aspect, just below its bifid termination, to a small soft simple fin-ray, which supports a delicate membrane inserted along the middle line of the back, a little way behind the spine. The supporting spine is articulated, as aforesaid, in a deep notch between two paired dorsal scales, and can be erected, and also folded down flat in the groove behind it; it is pierced longitudinally by a canal which passes up through it to convey vessels for the nutrition of the soft ray.

Peculiar light is thrown on the essential nature of the so-called dorsal finlets, by the structure of the last of these appendages in two of my specimens. In that measuring fourteen inches, the eleventh and last finlet has its spine represented by two separate and moveable lateral halves, each like a little narrow pointed scale, one-eighth of an inch long, placed on the front and sides of the root of the soft ray, which seems here to arise directly from the body of the fish. On careful dissection, I found that each of the two pointed bodies, representing the spine of the finlet, was, in fact, a process extending upwards from each lateral member of the first pair of the double series of joints, of which the fin-ray properly consists.

In the smallest specimen, measuring eleven and a half inches, the ray of the last finlet, here also the eleventh, looks more like the first ray of the caudal fin, with which it is closely connected. It arises apparently direct from the body; and has its joints hard and ganoid, like those of the rays of the last mentioned fin. But its structure shows indications of the development of a spine; and without it, the caudal has already the usual number of thirteen rays. The joints of the proximal half of the ray, seven in number, as far as I could make out with the magnifying glass, their divisions being still, though faintly, visible, are

fused together, and from the side of the last of those fused joints, a small pointed process, projecting upwards in the line of the ray, is seen on the left side, evidently representing the left point of the dorsal fin-spine. On the right side a pointed process of greater prominence is seen, but not so high up in the ray, apparently arising only from the third joint.

From this it is clear that each so-called dorsal "finlet" corresponds in fact to a single fin-ray, and is serially and entirely homologous with the individual rays of the caudal behind. Their manner of formation would seem to be as follows:—Each dorsal fin ray consists, as is usual, of a double series of articulations, and the lower of these, becoming ganoid on their surfaces, fuse together into an inflexible column—the basis of the so-called spine of the finlet. While this is going on, each of the right and left sets of fusing articulations throws out a lateral spiny process directed towards the extremity of the ray. These lateral processes also fusing together, form a ridge on each side, converting the columnar body into a spine flattened from before backwards, but those from the last pair of fusing joints project, of course, freely upwards, and form the two points into which the extremity of the spine normally divides. Thus it happens that the lower part, of what is in reality one fin-ray, comes to be metamorphosed into a flattened ganoid spine with bifid extremity, while the terminal portion remaining slender, soft, and flexible, now appears like an appendage of the same.

A very similar explanation of the formation of the dorsal finlets of Polypterus has been given by Steindachner.* In this allied genus the membrane of each finlet is supported by several soft rays, and the German ichthyologist has shown, that these are to be considered as resulting from the dichotomous division of one original ray.

XXXVI.—Notes on Metamorphic Ingenite [intrusive] Rocks. By G. H. Kinahan, M. R. I. A.

[Read June, 1870.]

In the Geological Memoir, to accompany sheet 105 of the Geological Map of Ireland, the writer of these notes suggested that many intrusive rocks, or the "ingenite rocks" of Forbes, both acid and basic, when not now in their normal condition, but when associated with schist and gneiss, were altered, having been metamorphosed by the same agent and at the same time that the associated sedimentary rocks were changed into schist and gneiss. Since this memoir was published the correctness of this suggestion has been called in question; still, however, no fact to disprove it has been put forward; and as to the writer the weight of evidence appears to be in its favour, perhaps he may be

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* *Ueber Polypterus Labradei* (n. sp.) *und P. Senegalus* (Cuv.) *aus dem Senegal.* Sitzungsberichte der Kais. Acad. der Wissenschaften in Wien. June, 1869, p. 105.

allowed to lay before the Society a short resume of the circumstances that led to this conclusion.

The late Director of the Irish branch of the Geological Survey, J. Beete Jukes, F. R. S., M. R. I. A., &c., seems to have been the first to call attention to the supposed metamorphism of this class of rocks, for he thus writes, when describing whinstone associated with granite: "This rock" (whinstone) has a certain resemblance to the trap associated with the Ballynea ash, and appears to me just such a rock as that was likely to form, if a portion of it were to be caught in and rebaked by the granite."* Subsequently the writer of these notes came to very similar conclusions, nevertheless they were independent, as it was not till long after he was fully convinced of the metamorphosed condition of many of the whinstones and felstones in the Co. Galway that he learned that Mr. Jukes had anticipated him.†

Previous to entering into the facts in connexion with the ingenite rocks, a few words must be said about the associated sedimentary or "derivate" rocks, necessary to explain what hereafter will be put forward as in favour of the metamorphism of the former.

The metamorphic derivate rocks occurring within the limits of the area contained in sheet 105 (Geol. Map of Ireland) are capable of a fourfold division, namely:—

1. The Schist series.
2. The Gneiss series.
3. The Foliated Granite, or Gneissoid Granite.
4. The Granite without Foliation.‡

These groups merge successively into each other; that is, the schist series into the gneiss series, the gneiss series into the foliated granite, and the latter into the granite without foliation. In the first group, although the rocks for the most part are schist, nevertheless there are some beds of gneiss. This naturally might be expected, some rocks being more easily altered than the rest, unless the original sedimentary rocks were all similarly constituted. Even the rocks now metamorphosed into schist, underwent different degrees of change, as, interstratified with typical mica-schist, will be found beds more or less unaltered. Besides these degrees of metamorphism, due to the original composition of the rocks, there are also changes due to the intensity of the metamorphising force, consequently in places the rocks will be more altered than in others. In the second group the mass of the rock is gneiss; however some beds of schist occur; and in the third group, the representatives of

* Memoir Geol. Survey ex. sheets 147 and 157 of the Map of Ireland, pp. 11 and 34.

† These particulars are mentioned to show that both Mr. Jukes and myself, independently in different localities, but from very similar evidence, came to similar conclusions.

‡ Nos. 3 and 4 are the rocks called "Galway Granite" in the Memoir. The rock called "Oughterard Granite" will not be referred to in these notes as it is evidently intrusive.

these schistose beds are apparent;* moreover, in the granite of the third group occur courses "of different colours and textures, and of slightly different composition." In the fourth group, no divisional lines dividing up the granite occur; however, in different portions, the constituents vary, forming distinct varieties of the rock.

Associated with all derivate rocks, no matter of what geological age, in some locality or another will be found ingenite rocks; therefore, it seems possible, if not highly probable, that in most, if not in all parts of the now metamorphosed derivate rocks, some of the ingenite rocks were contemporaneous with the original rocks; in which case it could scarcely be possible that, while those derivate rocks were being metamorphosed into schist and gneiss, the associated ingenite rocks remained unchanged. In the localities where the sedimentary rocks are very little altered, the associated ingenite rocks seem to be similarly circumstanced; for, when the sedimentary rocks are only slightly altered, an accompanying felstone may appear unchanged; while a little removed from this, where the former are changed into schist or gneiss, the latter will have become a rock similar in aspect to a typical gneiss, or perhaps a fine granite. On account of the changes in the intensity of the metamorphosing force, these rocks vary greatly, and in one place the dyke may be altered, while in another it is not, or, as is not uncommon, the outside of the dyke may be changed into gneiss or fine granites while at the centre it appears to be a normal felstone. Normal felstone have different structures—some have a platy rudely parallel structure, parallel or nearly so to the walls of the dykes; others are traversed with systems of lines more or less oblique to the strike of the dyke; in some there is a spheroidal structure, while others are more or less homogeneous and compact; nevertheless, in the latter, lines supposed to be those of viscid fusion, are more or less apparent, and these various structural characters in the felstones seem to establish a relationship between them and the dykes of gneiss or gneissite and the dykes of fine compact granite that are found traversing the metamorphic sedimentary rocks, and are supposed by the author to be metamorphosed felstones. In some dykes of gneissite there is a foliation parallel, or nearly so, to the walls of the dykes, while others have an oblique or spheroidal foliation; moreover, in many of the fine compact granites, there are lines very similar, if not identical, with the lines of viscid fusion, which gives a section of the rock a riband aspect.

These dykes of gneissite and fine granite are quite apparent in the schist series, and also in the gniess series (Groups 1 and 2), while in the foliated granite (No. 3) they are scarcely traceable, and they are not to be found in the granite without foliation (No. 4).

Somewhat similar relations exist between the whinstone and the metamorphic derivate rocks. In the schist series (No. 1), the whinstones are more or less altered according to the degree of metamorphism

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* For example, see Memoir, p. 34, where a section of some these schistose beds is figured.

in the associated sedimentary rocks. In the gneiss series (No. 2), they are always a highly crystalline rock, sometimes even apparently merging into a hornblendic granite; while among the granites (Nos. 3 and 4), they lose their individual character. Still, however, the places where they are supposed to have once existed can still be pointed out; in the first, by tracts of hornblendic granite, sometimes coming in irregularly, and breaking the continuity of the foliated granite (No. 3), or by patches containing more or less basic constituents, such as amphibole, titanite, ripidolite, &c., in the granite without foliation (No. 4).

The facts now enumerated, which are supposed by the writer to be in favour of the supposed metamorphism of ingenite rocks may be put in the following tabular form:—

First—In sedimentary or derivate rocks, of all geological ages, there are associated ingenite rocks. Therefore, it is highly probable that ingenite rocks existed among the sedimentary rocks that are now metamorphosed previous to their undergoing that change.

Second—If ingenite rocks existed among the derivate rocks previous to the latter being altered, it appears impossible that the former could remain unaltered while the sedimentary rocks were being metamorphosed into schist or gneiss.

Third—It is quite palpable that some of the basic ingenite rocks are interstratified with the schist and gneiss, therefore these rocks must be contemporaneous with them.

Fourth—Most observers seem to have come to the conclusion that the foliation in metamorphic rocks is induced by the most marked structural change in the original rock; and in the dykes of gneissite, or in the dykes of fine granite, the foliation or the structure is similar to one or other of the structures usually found in felstones.

Fifth—The ingenite rocks seem to be more or less altered from their normal condition in proportion to the metamorphism in the associated sedimentary rocks.

Sixth—In the granites (Nos. 3 and 4) the supposed metamorphic basic ingenite rocks do not occur, while the supposed metamorphic acid ingenite rocks are found in No. 3, but not in No. 4, seemingly proving that, on account of the difference in their fusibility, the former class was incorporated with the associated rocks much easier than the latter.

The principal facts that appear to be in favour of the novel suggestions, published by the author in the memoir referred to at the beginning of these notes have now been stated. The writer is fully aware that he has not proved his suggestions; still, however, previous to their being rejected, might he suggest that some experimentalist, with time and opportunities at his command, would test these statements by actual experiments? This to the author does not appear impossible, for if portions of the different kinds of ingenite rocks were subjected to extreme heat under great pressure the changes that occurred in their constituents and in their structure might be noted, and the so artificially-formed rocks compared with the natural ingenite rocks found associated

with the metamorphic sedimentary rocks. If, by the publication of this paper, some competent person is induced to try these experiments, and prove or disprove these suggestions, the author will be only too well repaid.

XXXVII.—Notes on Primitive Wooden Shovels imbedded in a Deposit of Iron Ochre, on the Property of the Right Hon. Major-General Dunne, at Clonaslee, Queen's County. By Dr. W. Frazer, F. R. G. S. I., M. R. I.. A.

[Read December, 1870.]

The interesting series of mining, or rather dredging, shovels of wood, seven in number, which I take this opportunity of exhibiting to the members of the Geological Society, are of unusually rude and primitive workmanship. They were obtained during the course of the last two years, in excavating a bed of iron ochre, discovered in the Queen's County, on the property of General Dunne. The exact situation of this deposit of ochre is in the north-west angle of the county, within a mile and a half of Clonaslee, and distant about six miles from Tullamore. Wide-spread bogs extend down the slopes of the Slieve Bloom mountains, and two streams, the Clodiagh rising from Barradoor mountain, and Goroch river from Slieve Bloom, join to form a common stream. Beyond the junction of these rivers, and to the west side, is the location of the ore. I must acknowledge, with thanks, the kindness of General Dunne, who transmitted these shovels to me through the hands of Mr. Stirling, of Tullamore, a gentleman who has raised considerable quantities of this ochre for some time past, and who further supplied me with all the particulars of their discovery, and with illustrative specimens of the ore.

The mineral is the ordinary brown hydrated oxide or iron ochre, small deposits of which are far from uncommon in the bottoms of our Irish bogs. Its importance is due to the exceptional amount in which it abounds in the locality where it is worked, and its special adaptation for purifying coal gas by the dry or "iron" process, a plan of late much recommended instead of the ordinary "lime" washing for removing sulphuretted hydrogen and sulphuric compounds from coal gas. Its fitness for this operation is such that it already forms a large item of traffic for supplying gas works in England and here, and the demand for it is, I understand, rapidly extending.

The bed of ochre is deposited in a compact mass, its thickness ranging, in the parts already explored, from two to twelve feet. It has already been excavated over a space measuring about 400 yards square; but its extent is as yet only conjectural, as it reaches under the adjoining bog. I made careful inquiry whether traces of animal remains, horns, &c., or implements of bronze, iron, or wood, other than the shovels had been obtained, but Mr. Stirling assures me that, although

the workmen were watching for matters of the kind, none have ever turned up. The shovels themselves cannot be considered rare, for upwards of fifty must have fallen into the hands of the men. They were scattered without regular order over a space measuring 200 yards in length by 300 wide or thereabouts. They were obtained without exception imbedded in the deposit of ochre, and, as a rule, completely sunk in it to a considerable depth; lying in every position, some were covered by upwards of six feet in thickness of iron ore; others lay only at a foot depth; in other words, some of these shovels had at least six feet of mineral deposit super-imposed on them, and upon this lay originally a turf bog of, say, six to eight feet in thickness.

One of the shovels, when uncovered, as it lay bedded in the ore, had a handle eighteen feet long; it was so soft that it was impossible to remove it without breaking. The longest handle of the specimens I obtained is about four feet in length, the next is between two and three feet long, and the other shovels are all fractured low down. When procured the wood was almost as soft as the putty-like deposit in which they lay, and it was difficult to extract them from it without special precautions; even when sent to me, after some weeks' drying, they were still soft, and they have now shrunk or split in many places. The primitive forms of these instruments and their evident adaptation for scraping or lifting heavy mud and ore from the bottom of a lake or lagoon, will at once be noticed. They are altogether unlike the spades or shovels at present in use, though well adapted to obtain a mineral deposit like iron ochre when it lay deep under water and uncovered by accumulations of mud or turf bog. The great length of the handle attached to one of these instruments would lead us to conjecture that the depth of the water must have been considerable when it required such long tools to reach the bottom of the lake; for, allowing even one-third of the handle for leverage, there would still remain twelve feet for the depth of the lake.

The process of recovering iron ore from lakes is practised at the present time in Sweden and Norway, where quantities of pisolitic brown oxide of iron is thus obtained with the assistance of wooden shovels; but, although there were numerous iron furnaces in different parts of Ireland down to the times of Elizabeth and James I., and even later, using wood for fuel until its increased scarcity compelled the smelters to cease their labour, I do not think such was the object with which this iron ochre was dredged. It, possibly, was employed to form a good and cheap paint, and a friend has offered the conjecture that it would suit for marking or "raddling" cattle. Whatever use was made of it, the large number of shovels found within a limited space shows there was either a tolerably large demand for the substance itself, or else that efforts at raising it were extended over a considerable period of time. I leave to antiquarians to conjecture at what happy period these shovels were made use of, and the special people who formed them, whether they were Norman, Elizabethan, or Crom-

wellian settlers, or earlier still, the native Celts; or even if a claim is set up for those universal originators of all things uncommon in Ireland—the Danes—I am willing they should be judged the original proprietors. For my own part I believe they are of rather primitive construction, and not unworthy of being recorded as illustrations of an early effort at Irish mining, or at least rude dredging for a mineral substance that at present possesses some commercial interest.

XXXVIII.—On the Geological Age of the Ballycastle Coal-field, and its Relations to the Carboniferous Rocks of the West of Scotland. By Edward Hull, M. A., F. R. S., F. G. S., Director of the Geological Survey of Ireland, with Palæontological Notes, by W. H. Baily, F. G. S., and L. S. (Plate XXIII.)

[Read January 11, 1871.]

Having recently had occasion to visit the coal-field of Ballycastle for the purpose of inquiring into its mineral resources on behalf of the Royal Coal Commission, I was struck by several features of resemblance which the rocks present to those of the Carboniferous district of the West of Scotland; and I have thought that a comparison of the geological relations of the two districts on opposite sides of the Irish Sea, may not prove uninteresting to the Society.

I wish in the first place, however, to state that I have no intention to present a general description of the Ballycastle coal-field to the Society on this occasion, or to refer to the subject further than may be necessary for the purposes of the comparison aforesaid. In course of time a complete examination of that interesting district will be undertaken by the Government Geological Surveyors, and after the able report made in 1829 by Sir Richard Griffith to the Royal Dublin Society,* any attempt at a general description of the structure and resources of this little coal-field would be, meanwhile, simply superfluous.

Though my visit to Ballycastle in the spring of this year extended only over a few days, yet, what I saw sufficed to convince me, that the Carboniferous rocks of that district are referrible to the type of those of the West of Scotland rather than to those of Tyrone, Leitrim, Kilkenny, and the South of Ireland, as well as of England and Wales.

Now, in order properly to explain my meaning, it may be useful to point out the true geological horizon of the coal-fields I have referred to, and I shall commence by referring briefly to those of England and Wales.

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* "Geological and Mining Survey of the Coal Districts of Tyrone and Antrim," by Richard Griffith. Dublin, 1829.

Fig. 1.

CLIFF SECTION AT GOBB COLLIERY.

(*See page* 265.)

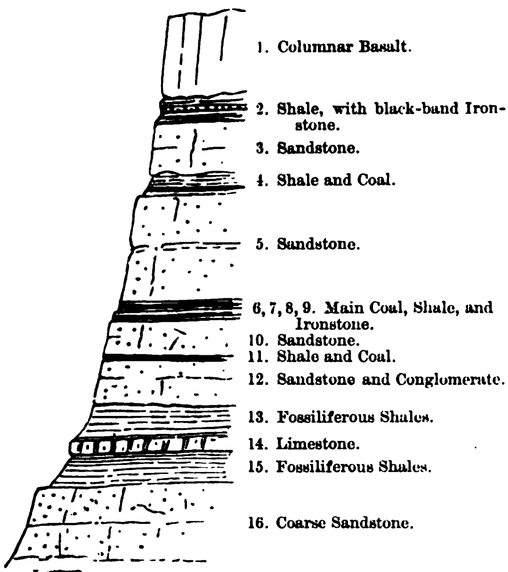
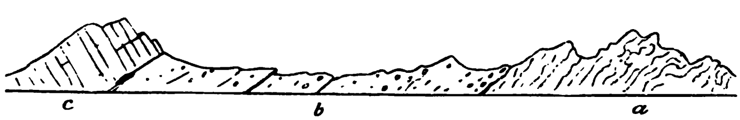


Fig. 2.

COAST SECTION AT MURLOCH BAY, SHOWING THE BASEMENT BEDS OF THE CARBONIFEROUS SERIES.



c...Bedded columnar Basalt.
b...Yellow and White Sandstone and Quartzose Conglomerate at the base of the Carboniferous Series; resting on
a...Foliated dark Mica Schist, with numerous Veins of white Quartz.

TO ILLUSTRATE MR. HULL'S PAPER ON THE GEOLOGICAL AGE OF THE BALLYCASTLE COAL FIELD.

Geological Horizon of the English and Welsh Coal-fields.

The general succession of these beds is as follows :—

Stage E. Upper, middle, and lower coal-measures.
,, D. Millstone grit.
,, C. Yoredale rocks.
,, B. Carboniferous limestone.
,, A. Lower limestone shale (forming the base of the Carboniferous rocks).

The above is the typical succession of the different stages throughout the whole of the coal-fields except those of the extreme north of England, where certain changes occur to which I shall presently allude. But throughout the English coal-fields, it is only in stage E that beds of workable coal occur, and to these the term "coal-measures," is strictly confined.

South of Ireland.—The coal-fields of Kilkenny, King's County, Kerry, and Clare, have like those of England, a basis of Carboniferous limestone; and still retaining, by way of comparison, the stages as developed in England, are capable of being arranged as follows :—

Stage E. (Not represented).
,, D. (Doubtfully represented).
,, C. So-called "coal-measures" of this district.
,, B. Carboniferous limestone.
,, A. Carboniferous slate, or lower limestone shale, &c.

Upon comparing these stages with those of England, it will be observed that "the coal-measures" of this part of Ireland occupy an horizon altogether different from, and considerably lower down than, the true coal-measures of England.

In the north of Ireland, however, the series approximates to that of England, as will be seen by the following comparison of the strata of the Tyrone and Connaught coal-fields.*

Connaught and Dungannon Coal-fields :—

Stage E. Coal-measures (with coal, &c.).
,, D. Millstone grit, } well developed in County Leitrim,
,, C. Yoredale rocks, } not so well in Tyrone.
,, B. Carboniferous limestone.
,, A. Lower limestone shale, yellow sandstone, and conglomerate.

* See Griffith's "Report on the Connaught Coal-field," 1818, pp. 20–23; and the late Mr. G. V. Du Noyér's Description of this Coal District, in the "Geologist," 1854.

Changes in the Carboniferous Rocks of England towards the North.

Returning now for a little to England in order to examine the changes which the Lower Carboniferous rocks undergo in their extension northwards, it is well known, as the result of the labours of Sedgwick, Phillips, and other geologists, that the Carboniferous limestone gradually deteriorates (as such) as it extends towards the Scottish Borders. In this direction, beds of shale and sandstone with coal make their appearance, dividing the solid limestone of Derbyshire into successive stages or bands, which thin out northwards in proportion as the sedimentary strata of sandstone and shale augment. Now, when we proceed further north, into Scotland itself, we find these changes still further carried out. The limestone beds, of which (according to Professor Phillips) there are ten in number in Northumberland* parted by as many beds of shale, &c., attaining a thickness of about 1120 feet, are found to have dwindled down to about one-tenth of these dimensions, and their place to be occupied by a great series of sandstones and conglomerates, shales, and clays, with ironstones and coal-seams; the whole forming what is known as the "lower coal-series" of Scotland.

The lower coal-series of the Clyde basin represents in effect the Carboniferous limestone of England and Ireland, under altered conditions; and at its base there occurs a thick series of red sandstones and conglomerates, which are very fully developed in Ayrshire and along the southern shores of the estuary of the Clyde; these are known as "The Calciferous Sandstones."

The general section is as follows; and we shall still, for the purpose of comparison, retain the lettering of the stages as above :—

General Section of the Carboniferous Rocks of the Clyde Basin.

Stage E. Upper coal-series, 840 feet.
,, D. } Sandstones and shales, feebly represented, about 500
,, C. } or 600 feet.†
,, B. Lower coal-series, consisting of six thin courses of marine limestone, from 50 to 100 feet in aggregate thickness, with interstratified grits, shales, coal, and ironstone; about 2200 feet.
,, A. Calciferous Sandstones; reddish calcareous sandstones, with contemporaneous trap rocks, &c., of great thickness (representing the Lower limestone shales of England).‡

The general and prominent feature in the Scotch series is the attenuation of the calcareous beds of the Carboniferous limestone stage,

* "Manual of Geology," p. 163.

† The Roslyn sandstone is considered by geological surveyors to be the representation of the millstone grit; but in the neighbourhood of Glasgow it cannot be identified.

‡ Explanation, p. 12, to Murchison's and Geikie's new Geol. Map of Scotland, 1862.

and their replacement by sedimentary strata with certain minerals, such as coal and ironstone, which are elsewhere found in the true coal-measures of stage E. The cause of this I have elsewhere shown to have been the existence, during the Lower Carboniferous period, of marine currents carrying sandy and muddy sediment from the northward. Now, as the existence of such sediment in the waters of the ocean is at the present day destructive of coralline life, so during this stage it was destructive of corallines, crinoids, and other marine animals, which were the great limestone builders of the Carboniferous period.

Special Features.—Amongst the special features of the Lower Carboniferous rocks of the west of Scotland, we may mention :—(1.) Earthy compact limestones, producing hydraulic cement. (2.) Black-band ironstones. (3.) Clay-band ironstones. (4.) Coal. (5.) Great development of red sandstones. (6.) Contemporaneous trap rocks (melaphyre, porphyrite, &c.), with beds of ash. As this last feature is not represented at Ballycastle (the trap-rocks of that district being eruptive), it may be omitted from our consideration in this place. The other features of resemblance I shall now briefly notice.

(1.) *Earthy Limestones.*—The limestones which occur at intervals throughout the Scotch Lower Carboniferous series, are generally in the form of thin compact earthy beds, differing much in appearance from the massive crystalline encrinital and coralline limestones of the north of England. The uppermost is the Garnkirt limestone, and the lowest underlies "the Hurlet Coal." Their combined thickness, in the Glasgow district does not exceed 100 feet. They contain Carboniferous limestone species of the genera *Spirifer*, *Productus*, *Rhynconella*, *Euomphalus*, &c., with crinoids and corals.

(2.) *Black-band Ironstones.*—The occurrence of black-band ironstones, interstratified with coal and black shales, is another feature. Though not exclusively found in the lower series, the principal beds are all found in a position below the upper marine limestone of Garnkirk, and therefore in the Carboniferous limestone series. The ironstones sometimes pass into coal, or cannal.

(3.) *Clay-band Ironstones.*—These occur in the same strata as the black-band seams, and I only mention them here as it will be seen they are also present at Ballycastle.

(4.) *Coal.*—Although the principal seams of coal are found in the upper series, a considerable number of thinner seams are found throughout the lower series, lying below the Garnkirk marine limestone. There is also "the Hurlet Coal" five or six feet in thickness, lying far down in the limestone series.

(5.) *Red Sandstones.* (*"Calciferous Sandstones"*).—The great development of red and yellow sandstones at the base of the Lower Carboniferous series, is a remarkable feature, and one which we shall find parallelled when we come to consider the Ballycastle district. These red sandstor es, sometimes calcareous—and containing plant remains—lie below the marine limestones, and may safely be considered to represent the Lower Limestone shale and yellow sandstone of the north of Ireland.

Having thus passed in rapid review the general, and some of the special, features of the Lower Carboniferous series of Scotland (the true representative of the Mountain Limestone and the subordinate lower shales), I think we shall find that these features are also characteristic of the Ballycastle coal-series, and that we shall be justified in considering the rocks of both districts, as the actual representatives in time of one another, and both as representing the Lower Carboniferous series of Britain.

Ballycastle Carboniferous Series.—These beds have been described by several authors,* and I only propose to refer to them here for the purpose of comparison with the Scotch series.

In general terms they may be described as follows:

(3.) *Upper Beds.*—Reddish and grey sandstone, sometimes coarse-grained and conglomeratic; and shales with several seams of coal, black-band, and clay-band ironstone.

(2.) *Middle Beds.*—Thin bands of fossiliferous limestone and shales.

(1.) *Lower Beds.*—Red and yellow sandstones and shale, with one seam of black-band ironstone, and beds of conglomerate at the base.

The entire thickness of the series is unknown, but it probably exceeds 1,200 feet. The strata over some portions of the coal-field are capped by massive columnar beds of basalt and dolerite.

I now proceed to give details of two or three sections, measured along the cliffs. Of these, Sir R. Griffith has already furnished in his "Report" several accurate sections, with illustrations.

General Coal-series in Ballycastle Bay (furnished by Mr. Archibald Gray, Mine Manager).

	Fms.	Yds.	Ft.
First coal (*Splint seam*)	0	0	3
Strata (sandstones and shales)	5	0	0
Second coal (*Hawksnest seam*)	0	0	3
Strata	40	0	0
Third coal (*Main seam*)	0	0	4
Strata	10	0	0
Limestone	0	2	2
Strata	40	0	0
Lower black band ironstone (about)	0	1	0

* By Dr. Berger and the Rev. W. Conybeare, in their paper on "The Geological Features of the North-East of Ireland," Trans. Geol. Soc. 1816. Mr. (now Sir R.) Griffith's "Survey of the Antrim Coal District," Report, 1829.

Section at Gob Colliery. (Fig. 1.)

This remarkable coast section, which is typical of the series, is given by Sir R. Griffith, and was also sketched by myself bed by bed. On comparing my own section with that of Sir R. Griffith, I find the upper portion corresponds exactly with his, but in the lower there is considerable divergence. The exact spots where the two sections have been taken may be different, which will in some measure account for the discrepancy. The total elevation of the cliff is 373 feet above the sea.

Cliff Section at Gob Colliery (showing relative Position of the Main and Coal Limestone.)

	Feet.	Inches.
1. Columnar basalt,	51	0
2. Shale with black-band ironstone,	18	0
3. Reddish sandstone,	42	0
4. Black shale, with coal,	15	0
5. Massive reddish and white sandstone,	81	0
6. *Main coal,*	4	0
7. Black shale and fire clay,	2	0
8. Impure coal,	2	0
9. Black shale,	16	0
10. Reddish sandstone,	30	0
11. Black shale and coal,	4	0
12. Reddish sandstone—sometimes a conglomerate,	36	0
13. Grey calcareous shales, with bands of flagstone,	26	0
14. Compact earthy limestone, with shale parting,	9	0
15. Strong calc. shale, sandy in lower part,	20	0
16. Massive coarse sandstone (white),	30	0

Sections at Mr. M'Gildowny's Mine (showing Details of Coal and Ironstone.)

	Feet.	Inches.
1. Coarse reddish grit, becoming fine-grained and white at bottom,	,,	,,
2. Black shale roof,	1	6
3. *Main coal* (variable) . . . . . . 3 feet to	4	6
4 Black-band ironstone,	1	0
5. Dark shale,	5	0
6. Clay-band ironstone—very rich (variable),	0	7
7. Black shale,	0	8
8. Black-band ironstone (variable),	1	0
9. Black shale,	8	0
10. Yellow sandstone, (more than)	15	0

The above sections will suffice to give an idea of the upper and central portions of the Carboniferous series. These beds are underlaid by a thick series of reddish sandstone, described by Sir R. Griffith as

underlying the magnificent mural cliffs of columnar dolerite of Fair Head. The base of the whole series is formed of yellow and white sandstone, and quartzose conglomerate, which, in Murloch Bay, may be seen resting directly on foliated mica-schist, and dipping towards the north-west, under the rocks of Fair Head. This section is shown along the shore at Boat Port, and is represented in the sketch (Fig. 2), taken at Boat Port, Murloch Bay, showing the basement conglomerate of the Carboniferous Series.

Limestone of Colliery Bay.—As bearing upon the age of the Carboniferous series in this district, by far the most important member is the band of limestone referred to above (p. 264), as lying ten fathoms below the *main seam of coal,* and also in the section at Gob Colliery. This bed varies from eight to nine feet in thickness, and is generally divided into two portions by a band of shale. It may be observed cropping out along the coast cliff at Star Colliery, as far as North Star Dyke, before reaching which it dips under low water, to the eastward, but reappears at Gob Colliery; and, opposite Carrickmore, rises into the cliff, and is lost to view beneath the basalt. This band of limestone is compact, earthy, probably dolomitic, and is generally well stored with shells and crinoidal remains. On seeing it, I was at once struck by its similarity to the Carboniferous limestone bands of the west of Scotland, near Glasgow and Paisley; some of which (as the "Arden limestone") possess hydraulic properties, and are worked for hydraulic cement.* It lies between two beds of shale, also charged with remains of mollusca, &c.; these beds form grassy slopes above and below the little scarp of the limestone in Colliery Bay.

This band of limestone may be regarded as occupying the position of the lower division of the Carboniferous limestone series, as it seems to be the first we meet with in the ascending order. If this be so, then the overlying strata with coal are the equivalents of the upper beds of the same formation under the Scotch Lower Carboniferous type. In this view I am supported by Mr. W. H. Baily, F. G. S., who, in company with Mr. A. M'Henry, has visited the district in order to investigate its palæontological characters. Mr. Baily finds that the fossils, with which this band is richly charged, are Carboniferous Limestone forms, for the most part *representing the lowest beds of that formation.* A list of these fossils is subjoined (p. 272).

This view is further corroborated by a comparison of the fossil forms found in the limestone with those from the Carboniferous limestone series of the west of Scotland. In the "Transactions of the Geological Society of Glasgow," very complete lists are given of fossils from this series in the district of Paisley. We find that out of thirty-three species

* Mr. J. M'Gildowny, of Clare Park, informs me that the limestone of Ballycastle Bay is hydraulic, in this respect resembling that of the west of Scotland.

from Ballycastle, about fifteen, or fifty per cent. are common to the Carboniferous limestone beds of these districts.*

It is at present uncertain whether there are other beds of limestone interstratified with the coal-bearing rocks which overlie the limestone band of Colliery Bay. Mr. Gray informs me that none have been found by him; but Sir R. Griffith gives the details of a boring, made in 1816, at Barnish,† in strata supposed to overlie the main coal, in which a bed of limestone was reached at a depth of seventy-one yards. As the strata in the boring do not at all correspond with those overlying the limestone of Colliery Bay, we may assume, with Sir R. Griffith himself, that the bed here proved is not the same as that in Colliery Bay, but one probably occupying a higher position in the series.

The limestone of Colliery Bay is probably the lowest, or nearly the lowest, calcareous band (corresponding to the position of the Hurlet limestone of Paisley); and if we take the lower coal-series of Scotland‡ as a guide to the identification of the Ballycastle coal-series, we arrive at the conclusion, that the beds overlying the limestone of Colliery Bay belong to the Carboniferous limestone series, as well as those in immediate contact with the limestone itself.

Black-Band Ironstones.—The occurrence of these peculiar carbonaceous ironstones at Ballycastle is another feature of relationship to the lower coal-series of Scotland. Four of these are known; the uppermost 150 feet above the main coal (see section of Gob Colliery above, p. 265), then two in close proximity to this seam, and one 240 feet below the limestone of Colliery Bay. In Scotland, nearly all the black band ironstones occur in the Carboniferous limestone series.

Palæontological Evidence.—This is at present far from complete, but so far as it goes, fully bears out the view of the identification of the whole Ballycastle coal-series with the Lower Carboniferous rocks of Scotland. The species which occur in the limestone of Colliery Bay, and the shales both above and below it, identify it with the Lower Carboniferous series. Some of these species are recorded by Mr. W. H. Baily from specimens collected by himself and Mr. A. M'Henry, the collector of the Survey. But not only have we Lower Carboniferous species in the limestone, but also in beds associated with the coal-seams themselves. At the Salt Pans Colliery, the shales lying between the "Splint" and "Hawksnest" coals contain in abundance *Lingula squamiformis*, a fossil which, as far as we have been able to ascertain, occurs only in the Carboniferous limestone series. In this position it is found in the lower coal-series of the west of Scotland, also low down in the

* Mr. M'Phail on the Geology of the Nitshill District, and Mr. Craig on the Geology of the Dalry District, "Transactions of the Geological Society of Glasgow," vol. iii. pt. 2.

† "Report," &c. *sup. cit.* p. 69.

‡ Upwards of 2000 feet thick, consisting of grits, shales, coal, ironstone, and their bands of limestone. See p. 262, *supra*.

Carboniferous limestone of the north of England, and in a similar position at Enniskillen. Taken by itself this may not be considered as determining the geological position of the beds, but it is at least a valuable corroboration of the views here advanced when taken in conjunction with the other features of evidence.

Conclusions.—It may be fairly stated that there is a strong general relationship, approaching identification, between the coal-series of Ballycastle and the Lower Carboniferous rocks of W. Scotland, representing the Carboniferous limestone of England and Ireland. We find a similar series of reddish grits and conglomerates at the base, overlaid by similar earthy limestones, black-band and clay-band ironstones, beds of coal, and coarse-grained grits and shales; while the palæontological relations are, as far as known, analogous. Recurring then to the plan adopted above of dividing the Carboniferous rocks into representative stages, I suggest the following for those of Ballycastle.

Geological Stages of the Ballycastle Rocks (*see above, p.* 262).

Stage E. Coal-measures (not represented).
,, D. Millstone grit (probably not represented).
,, C. Yoredale beds (uncertain).
,, B. Carboniferous limestone; coal-series of Ballycastle Bay and Murloch Bay, down to the shales underlying the limestone of Colliery Bay.
,, A. Limestone shale, yellow sandstone, &c.; red sandstones and conglomerates below the limestone, Colliery Bay, Carrickmore Bay, and Murloch Bay.

Changes in the Carboniferous Limestone Series of Ireland in its Extension Northwards.—The views advocated are in accordance with observation as applied to Ireland itself. The Carboniferous limestone of England undergoes, as we have already seen, a complete revolution in its mineral character when traced from the centre of that country into Scotland. Such changes involve certain physical conditions of the period of more than local influence, and it would have been strange if the Lower Carboniferous rocks of Ireland had escaped similar alterations of mineral character. In all probability the variations in both countries were very nearly identical. In each case during the formation of the limestone in the centre of England and of Ireland, in clear and limpid waters teeming with organised beings (limestone builders), these waters in a northerly direction became charged with muddy and sandy sediment; and were also in more immediate proximity to the land from whence this sediment was derived. This proximity gave rise to terrestial conditions productive of beds of coal, and ironstone.

On a former occasion I have shown, that in formations composed partly of calcareous and partly of sedimentary members, the mutual relations of these are of an opposite character, and that the direction in which the one set of strata augment, the other will be found to undergo

attenuation.* Into the reasons for this law I need not here enter, but the Lower Carboniferous rocks of Ireland are an illustration of its truth. In the central portions of the country, this limestone assumes its greatest proportions, and the amount of sedimentary matter associated with it is comparatively unimportant. On the other hand, both to the southward and to the northward, the sedimentary materials sensibly augment to the disadvantage of the calcareous.

Confining our attention to the changes in a northerly direction, the observations of Griffith and Portlock fully bear out the statement I have made. This latter authority shows that in the county of Derry, the limestone is represented by a few nodular calcareous beds, irregularly interposed amongst sandstones and shales of considerable thickness,† and contrasts the greater development of limestone in a south-westerly direction as compared with that towards the north-east, where sandstones and shales predominate.‡ A change in the direction of the Lower Carboniferous type of Scotland takes place in the Carboniferous limestone of Fermanagh when traced into Londonderry; and, as I maintain, is still further carried out in the case of the Ballycastle coal-series, which lies in a position intermediate between Fermanagh and Derry on the one hand and the district of the Clyde basin on the other.

This gradual change of mineral character will be apparent from the following comparative section along the line here indicated.

Changes in the Lower Carboniferous Series along a North-easterly Line from Ireland to Scotland.

	Fermanagh.		Londonderry.	Ballycastle.	Clyde Basin.
Stage D.	Millstone grit,	250 ft.?	(uncertain).	(absent).	(Sandstones, &c.).
„ C.	Yoredale Beds,	650 ft.?	(uncertain).	(uncertain).	(uncertain).
„ B.	(A) Upper Limestone,	250 „?	Thick series of sandstones and shales with thin bands of limestone.	Sandstones and shales with coal, b. b. iron-stone and earth lime-stone.	Sandstones and shales with coal and b. b. iron-stone, and thin bands of earthy limestones.
	Dark shales, and earthy Limestones ("calp,")	1000 „?			
	Blue Lime-stone,	500 „?			
„ A.	Shales, Sand-stones, and Conglomerates,	200 „	Yellow and red sandstones and conglo-merates.	Red sand-stones and conglome-rates.	Calciferous sand-stone series.

* "Quarterly Journal of the Geological Society of London," vol. xviii. p. 127.

† "Geological Report, Londonderry," &c., p. 561.

‡ I am glad to observe that Portlock refers to the resemblance of the Lower Carboniferous series of East Derry to the Scottish series. "Report," pp. 564–5. See also Griffith's Geological Map of Ireland.

From this table it will be seen that the changes in the Lower Carboniferous series are gradual along the line here indicated. A similar comparison might be instituted with similar results along a line drawn from the centre of Ireland through Ballycastle. In all cases it would be found that the sedimentary materials gradually replace the calcareous as we proceed northwards.

Physical Geography of the Period.—These observations lead to the inference that, throughout the Lower Carboniferous period, a large tract of land (or a continent) occupied the region of the North Atlantic Ocean. This primæval Atlantis was the source of the sedimentary materials of the period, which were distributed in diminishing quantities southward.

During this period, the ocean over the tracts now forming the central portions of England and Ireland was, for the most part, limpid and free from sediment (except during the stage of the calp in Ireland); and in this limpid sea, thus favourable to the development of marine life, those living forms, which were the limestone builders of the period, flourished, and the limestone of the Lower Carboniferous period was developed in its full vertical dimensions. From this central position it thinned away northwards, where it was replaced by sedimentary strata.

Towards the north-east and north, terrestrial conditions sometimes prevailed, favourable to the growth of plants and the formation of coal or ironstone.

During the same period similar terrestrial conditions prevailed towards the south-west of the British islands, giving origin to the sedimentary strata of the Lower Carboniferous period in Devonshire and the southern districts of Ireland.

Appendix to Mr. Hull's Paper.

XXXIX.—On the Fossils of the Ballycastle Coal-field, Co. Antrim. By Wm. Hellier Baily, F. G. S., &c.

At Mr. Hull's request I append a note to his paper on the fossils formerly collected from this coal-field, and others recently obtained by myself and Mr. Alexander M'Henry, of the Geological Survey.

The following are the species of plants determined:—

[The mark × prefixed to species is intended to indicate its comparative abundance.]

Sigillaria reniformis (Brong.) in shale.
Stigmaria ficoides (Brong.), with attached rootlets, in shale.
× × „ „ „ in sandstone.
„ „ var. undulata, in sandstone.
Aspidaria quadrangularis (Presl.) Morris C. Brit. Foss. 1854, p. 2.
„ syn. Lepidodendron tetragonum (Sternberg) in shale.
Lepidostrobus variabilis (Lindley) in shale.

Sagenaria dichotoma (Sternberg).
syn. Lepidodendron Sternbergii (Brong.). in shale and sandstone.
" " (Sternb. sp.), according to Geinitz.
syn. Lepidodendron aculeatum (Sternb.) in sandstone.
" Veltheimiana (Goeppert).
syn. Knorria imbricata (Sternb. sp.) two varieties in sandstone.
× × " rimosa (Presl.) in sandstone.

Although but few species are enumerated in this list of fossil plants, they are such as appear to indicate an alliance with a Lower Carboniferous flora. *Sigillaria*, with its roots or rhizome *Stigmaria*, is of frequent occurrence; this group, including *Lepidodendron*, to which it is closely allied, and its fruit *Lepidostrobus*, belongs to the Lycopodiacea, and is the most important and universally distributed of all the Coal Measure plants. To the genus *Sagenaria* of Brongniart, *Lepidodendron* of Sternberg, also belonging to the family Lycopodiaceæ, Professor Goeppert refers *Knorria imbricata*, which he considers to be identical with *Sagenaria Veltheimiana*, the most common species in the lower carboniferous rocks. This species is stated by Professor Geinitz* to occur in the Coal formation at several localities in Saxony, and by F. A. Roemer in the Posidonomya schist formation at Lauthenthal, and in the Newer grauwacke of Clausthal, &c. In Irish strata it has been identified by me in sandstone, from Carnteel, Tyrone, probably equivalent to that of the Ballycastle section; in the carboniferous slate of Tallow Bridge, County Waterford, where it is remarkably abundant; also in the upper old red sandstone of Kiltorcan, County Kilkenny. This plant, under the name of *Knorria imbricata*, is also stated by Professor H. R. Goeppert† to occur in the Transition formation (Grauwacke) in Silesia; at Magdeburg in Saxony; in the province of Perm, Russia; and from the coal mines of Orenburg, on the borders of Asia; whilst Lindley and Hutton record its occurrence in the Ketley coal-field of Shropshire.‡ Some of the stems of *Sagenaria rimosa*, are nearly a foot in diameter, and are, in the pinkish sandstone, associated with numerous other plant fragments, particularly Stigmaria, possibly the Rhizomes or roots of this and allied species.

The absence of *Ferns* and jointed *Calamites*, which are usually so abundant in the true coal measures, and the presence of *Sagenaria* (or *Knorria imbricata*), uniformly striated and spirally imbricated plants, is a remarkable feature in this collection from the Ballycastle collieries, offering considerable support to the probability of their alliance with the flora of the Carboniferous limestone and culm.

* "Darstellung der Flora des Hainichen Ebersdorfer," &c., p. 57.
† "Les Genres des Plantes Fossiles," 1841.
‡ "Fossil Flora of Great Britain," vol. ii., p. 43.

The fossils occurring in the beds of limestone and associated shales are principally Molluscan shells, and are, for the most part, typical Carboniferous limestone fossils, some of them being exclusively characteristic of the lower limestone strata.

The following is a list of the species from the limestone and shale :—

ZOOPHYTA.

× × × Chætetes tumidus.

ECHINODERMATA.

× Archæocidaris Urii.
× × × Poteriocrinus crassus.
,, quinquangularis (?)
Actinocrinus (species indeterminable).

CRUSTACEA.—*Trilobita.*

Phillipsia Derbiensis.
Griffithides longiceps.

MOLLUSCA.—*Polyzoa.*

Ceriopora gracilis.
Fenestella antiqua, syn. F. plebeia M'Coy.

Brachiopoda.

× Productus giganteus.
× ,, longispinus.
× ,, semireticulatus.
× × × × Chonetes Hardrensis.
× × Spirifera lineata.
× × ,, bisulcata.
× × × Rhynchonella pleurodon.
× × × Lingula squamiformis (in black shale above the limestone).

Conchifera.

Aviculopecten (species indeterminable)
× × × Axinus deltoideus.
,, (species indeterminable).
× × × Leda attenuata.
Cypricardia cuneata ?
Edmondia, (species indeterminable).
Sanguinolites discors (?)
Myalina Verneuilii ?

Gasteropoda.

Macrocheilus ovalis.
Murchisonia angulata De Kon. (not Ph. Pal. Foss).
Pleurotomaria (species indeterminable).

Nucleobranchiata.

× × Bellerophon Urii.

Cephalopoda.

Orthoceras Steinhauerii.
,, dactyliophorum.
,, subcentrale (?)

PISCES.

Helodus planus (?) palatal teeth.
Ctenacanthus, defence spine, in black shales above limestone.
Amblypterus (?) Portlock Geol. Rep., p. 462., black shales, do.
Fish scales, bones and teeth, black shales, do.

On referring to the above list it will be seen that only one kind of Coral was observed—*Chætetes tumidus* (Stenopora of Morris's Catalogue of British Fossils), a small branching variety of a species belonging to the *Favositidæ.* It is abundant on the surfaces of some of the shales, accompanied by numerous Crinoid fragments, and is a characteristic carboniferous limestone species, frequent in the lower shales of the series.

Spines of *Archæocidaris Urii,* an Echinoderm characteristic of the lower shales of the Carboniferous limestone in Ireland, are not unfrequent on the weathered surfaces of some of the limestone slabs. This species is included in the lists of Carboniferous limestone fossils given in Mr. Hugh M'Phail's paper on the Levern Valley, Renfrewshire,* and that of Dalry, Ayrshire, by Mr. Robert Craig.†

Crinoid stems and joints abound in the limestone and associated shales of the section exposed on the Ballycastle shore. The large stems referred to, *Poteriocrinus crassus,* I believe to be exclusively a limestone species, in Ireland it is of frequent occurrence in the lower shales, together with *Actinocrinus,* the species of which from these beds are indeterminable.

Crustacea of the order Trilobita are represented by two species which appear to be identical with *Phillipsia Derbiensis* and *Griffithides longiceps,* both exclusively confined to the Carboniferous limestone.

Polyzoan mollusca were found to be rare, two forms only having been recognized in the limestone, *Ceriopora gracilis* and *Fenestella antiqua* (*F. plebeia,* M'Coy), both of which are recorded as having a stratigraphical range from the Upper Devonian to the Carboniferous limestone series.

Of Brachiopoda eight species were collected from the limestone and associated shales; of these, *Productus giganteus, longispinus,* and *semireticulatus,* characteristic Carboniferous limestone species, are included in the lists of fossils from Scotch strata, before alluded to; an allied shell, *Chonetes Hardrensis,* was found to occur in the greatest profusion, cover-

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* "Trans. Geol. Soc. of Glasgow," vol. iii., pt. 2, p. 534, *et seq.*
† *Ibid.*, p. 271, *et seq.*

ing the surfaces of slabs and detached in the shales, showing its finely striated exterior, and the interiors of both valves in beautiful preservation. This small species is found, as recorded by Mr. Thomas Davidson,* in the limestones and shales of many English, Scottish, and Irish localities. Its stratigraphical range is stated to be from the Devonian to the Coal measure series. In Ireland, I have identified it from coal measures in the County Clare, at various localities in carboniferous limestone, and the lower shales; in the Scotch lists before mentioned it is stated to occur in upper, middle, and lower limestone.

Spirifera bisulcata, a species common in the Coalbrook dale collieries, and *S. lineata*, exclusively a Carboniferous limestone species, are not uncommon in the limestone on the Ballycastle shore. In the Scotch lists these species are included as occurring in upper, middle, and lower limestone.

Rhynchonella pleurodon is abundant in the shales of the Ballycastle limestone ; it may be considered a characteristic limestone fossil. The stratigraphical range of this species, as given in Morris's Catalogue, is from the Upper Devonian to Carboniferous limestone; according to the Scotch lists it occurs in upper limestone.

Lingula squamiformis is a frequent fossil in the black shales above the limestone near the Salt Pans Colliery, being associated with branching plants and fish remains; it is exclusively a Carboniferous limestone fossil, occurring in Ireland, most frequently in the lower shales. In the Scotch lists it is recorded as occurring in the upper limestone.

Of the Lamellibranchiata, or ordinary bivalve shells, about eight species were collected from the limestone and shales, the most abundant being *Axinus deltoideus* and *Leda attenuata;* the former species having a range from Upper Devonian to Carboniferous limestone, the latter occurring in Carboniferous limestone and shales at various localities in England and Scotland and Ireland. This species is included in the Scotch lists from the middle and lower limestone. Of the remaining bivalve shells, those determinable are exclusively Carboniferous limestone species.

Only three distinct forms of univalve shells were observed, all being species exclusively from Carboniferous limestone.

A Nucleobranch shell, *Bellerophon Urii*, was found to be not uncommon in the limestone and associated shales. In the catalogue of British fossils its range is given as Upper Devonian to carboniferous limestone; it has been identified by me from Coal-measure shales in the County Limerick, and lower limestone shales in the County Cork. It is included in the Scotch lists as occurring in the middle and lower limestone.

The few Cephalopod shells, collected from the limestone and shale of Ballycastle, are small but characteristic; two species only have been satisfactorily identified, viz., *Orthoceras dactyliophorum* and *O. Steinhauerii;* the former has also been identified from the limestone at St. Doulagh's,

* "British Carboniferous Brachiopoda," Pal. Soc., p. 187.

County Dublin, and the Coal-measures of Foynes Island, County Limerick, and the latter from the Lower Carboniferous limestone of the County of Cork and the Coal-measures shales of Loughshinny, County Dublin, and corresponding shales in the County Meath.

From the black shales above the old Salt Pans Colliery, in which the Lingula squamiformis were so plentiful, we obtained a small fish spine, probably of the genus *Ctenacanthus*, accompanied by scales and other fish fragments. In the small collection formerly made from Ballycastle (Portlock series), now exhibited at the Royal College of Science, Stephen's Green, Dublin, with the collection of the Geological Survey of Ireland, is a considerable portion of a small fish which has been, doubtfully, referred to *Amblypterus*, by General Portlock,* and appears to have been obtained from the same dark shales. From the limestone shale on the shore we collected two small palatal fish teeth in juxtaposition, which appear to resemble *Helodus planus*.

The absence of the usual Coal-measure assemblage of fossils, such as the Ferns and Calamites, amongst the plants already alluded to, and amongst Molluscan shells, that of *Aviculopecten papyraceus*, *Posidonomya membranacea*, and *Goniatites crenistria*, which are usually present in such profusion in the Upper Carboniferous or true Coal-measure strata, together with the occurrence of so many species of characteristic Carboniferous limestone fossils, some of them being even peculiar to the lower limestone series, appears to me to assist materially in confirming the author of the preceding paper in his views as to the correllation of these strata with those of the west of Scotland, and consequently, increases the probability of their belonging to the lower division, or Carboniferous limestone series.

XL.—Report of Council for the Year ending February, 1870.

At the close of another year of the Society's history, the Council are happy to be able to report that the affairs of the Society are in as satisfactory a condition as at the commencement of their term of office. In a financial point of view, the Society is even more prosperous than it has been for the last few years, and the scientific value of the work done by the Society is, we believe, still occupying as high a position as heretofore.

During the past year seven have been removed from the ranks of fellowship by death, three of whom were specially interested in the Society. Professor Joseph B. Jukes, John Good, and Dr. C. P. Croker. The first of these, Joseph Beete Jukes, was at different times Secretary, Councillor, Vice-President, and President of the Society; and, though English in birth and education, he thoroughly identified himself with the Irish School of Geology. For the period of time in which he occupied the position of local director of the Geological Survey of Ireland, he used all the opportunities which his official position

* Geological Report on Londonderry, &c., p. 462.

afforded to him to unravel the difficulties which present themselves in the geological structure of Ireland, and thereby he has raised for himself the best and most lasting monument to his memory in the thorough elucidation of the palæozoic formations of the south and west of Ireland. The past numbers of the Journal of the Society contain many of his contributions to science, and among these, we may name as important his papers on the Geology of the County Waterford, County Wicklow, Arklow Head, Cahir-conree Mountain, County Dublin, on the formation of river valleys in the south of Ireland, on indented bones of Cervus megaceros, on the relations of the Devonian and carboniferous rocks of the south of Ireland. His last labours were devoted to the comparison of the rocks of Devonshire with those of the south of Ireland, as showing the true relations which subsist between the carboniferous, Devonian, and the old red sandstone formations; and although many geologists may dissent from the conclusions which he has drawn regarding these relations, yet it is impossible to read his papers on the subject without being convinced of the skill and experience which he possessed in field geology, and the thoroughly reliable nature of the facts which he described. Even when incapacitated from attending regularly to his duties by ill-health, he was often present at our Council meetings, and his untimely death, accelerated by mental overwork, we deeply deplore. In Mr. John Good, we have lost one of our most active and zealous Members of Council; one who was ever ready to give a willing assistance to any plans for the advancement of science; and who, though diffident in expressing his opinions, yet by his practical common sense frequently assisted in throwing light on many problems of scientific importance. Dr. Croker was for thirty-six years one of the most respected Fellows of the Society, who, though he did not contribute any practical geological work to the proceedings of the Society, being engaged in the labours of medical practice, yet always took a deep interest in scientific progress.

We have gained seven new Fellows during the past year, and have lost by resignation five, thus leaving the roll of Fellowship five fewer than at the close of our last year.

During the past Session, your Council have transferred the library of the Society from their Council-room, No. 35, College, to the College Library, thereby rendering it more easy of access to all those who wish to consult this valuable collection of geological works. For this transfer the Society have received £100 from the Board of Trinity College, on condition that all publications received by the Society in exchange for the Journal shall be from time to time added to the College Library.

Among the papers read during the past Session were several of interest on Mineralogy, and among the most remarkable of these was one on the discovery of Albite Felspar in the Dalkey Granite by Mr. W. H. S. Westropp. This paper adds a new link to the chain of investigation of the value of granites made from time to time by Fellows of this Society. The existence of albite in the granites of Mourne and Cornwall has been ascertained by the Rev. Dr. Haughton, and its dis-

covery in the Leinster granite was predicted by him, although no specimens of it had been obtained until Mr. Westropp found those which were the subject of the before-mentioned paper. This discovery corroborates the theory of the relationship of the three great eruptive granite masses of Mourne, Leinster, and Cornwall, as distinguished from the true metamorphic granites of Donegal and Skye.

Two interesting papers have been read before the Society by Dr. Lauder Lindsay, of Perth, on the subject of the present discovery of gold in Scotland, and the history of gold-seeking in that country, in which many particulars are given of the comparative geology of the auriferous districts of Scotland and those of New Zealand and Australia.

Our most important Palæontological paper was that from the pen of Professor Traquair, on Griffithides mucronatus, in which the true form of that interesting carboniferous trilobite is carefully and accurately described for the first time.

During the past year the joint meetings of this Society and the Royal Zoological Society have been held, and they have been well attended, and appreciated by the Members of both Societies.

APPENDIX TO ANNUAL REPORT.

No. I.

LIST OF FELLOWS, CORRECTED TO JUNE 30, 1870.

Fellows are requested to correct errors in this List, by letter to the Hon. Secretaries, 35, Trinity College, Dublin,; or to the Assistant Secretary.

OFFICERS OF THE SOCIETY FOR THE YEARS 1870-71.

PRESIDENT.—The Earl of Enniskillen, F.R.S.

VICE-PRESIDENTS.—R. Callwell, Esq.; John Barker, Esq., M.D.; Colonel Meadows Taylor, M.R.I.A.; J. Emerson Reynolds, Esq.; Sir Robert Kane, F.R.S.

TREASURERS.—William Andrews, Esq.; Samuel Downing, LL.D.

SECRETARIES.—Rev. S. Haughton, M.D., F.R.S.; Alexander Macalister, Esq.

COUNCIL.—Gilbert Sanders, Esq.; Alphonse Gages, M.R.I.A.; B. B. Stoney, C.E.; W. Fraser, M.D., M.R.I.A.; Joseph O'Kelly, Esq.; George Dixon, Esq.; Rev. H. Lloyd, Provost, T.C.D.; Alexander Carte, M.D., F.L.S.; W. H. S. Westropp, M.R.I.A.; C. R. C. Tichborne, Esq.; Sir Richard Griffith, Bart., LL.D.; Rev. Maxwell Close, M.A.; Francis M. Jennings, F.C.S.; Ramsay H. Traquair, M.D., Robert S. Reeves, M.A.

HONORARY FELLOWS.

Elected.		
1844.	1.	Boué, M. Ami, For. Mem., L.G.S., *Paris.*
1865.	2.	Burton, Captain, R. F., H. M. Consul, *Santoz.*
1861.	3.	Daubrée, M. Membre d l'Institute, 91, *Rue de Gréville, St. Germains, Paris.*
1861.	4.	Delesse, M., Ingénieur des Mines, *Paris.*
1865.	5.	Des Cloiseaux, M., Prof. of Mineralogy, *Jardin des Plantes, Paris.*
1861.	6.	De Serres, M. Marcel, *Montpelier.*
1861.	7.	Deville, M. C. Ste Claire, *Paris.*
1861.	8.	Deville, M. H. Ste Claire, *Paris.*
1861.	9.	De Koninck, M. L., For Mem., L. G. S., *Liége.*
1861.	10.	Geinitz, M. H. B., For. Mem., L. G. S., *Dresden.*
1863.	11.	Hunt, Dr. T. Sterry, F. R. S., *Montreal.*
1844.	12.	Lyell, Sir Charles, F. L. S., 73, *Harley-street. London, W.*
1861.	13.	M'Clintock, Sir Leopold, R. N., 21, *Merrion-square, North.*
1844.	14.	Murchison, Sir Roderick I., F. R. S., 16, *Belgrave-square, London, S.*
1832.	15.	Sedgwick, Rev. A., F. R. S., *Cambridge.*

HONORARY CORRESPONDING FELLOWS.

1859.	1.	Gordon, John, C. E., *India.*
1859.	2.	Hargrave, Henry, J. B., C. E., *India.*
1859.	3.	Hime, John, C. E., *Ceylon.*
1858.	4.	Kingsmill, Thomas W., *Hong Kong.*
1855.	5.	Medlicott, Joseph, *India.*
1854.	6.	Oldham, Thomas, F. R. S., *Calcutta.*

FELLOWS WHO HAVE PAID LIFE COMPOSITION.

1853.	1.	Allen, Richard Purdy, 10, *Bessboro'-terrace, N. C. Road.*
1861.	2.	Armstrong, Andrew, 16, *D'Olier-street.*
1857.	3.	Carson, Rev. Joseph, D. D., S. F. T. C. D., *Trinity College.*
1857.	4.	Dowse, Richard, *Mountjoy-square.*
1861.	5.	Fottrell, Edward, *Fleet-street.*

Elected.
1862. 6. Frazer, W., M.D., M.R.I.A., *Harcourt-street.*
1857. 7. Greene, John Ball, 6, *Ely-place.*
1848. 8. Haughton, Rev. Professor, M.D., F.R.S., 40, *Trinity College.*
1862. 9. Henry, F. H., *Lodge Park, Straffan, Co. Kildare.*
1850. 10. Hone, Nathaniel, M.R.I.A., *St. Doulough's, Co. Dublin.*
1861. 11. Hone, Thomas, *Yapton, Monkstown, Co. Dublin.*
1831. 12. Hutton, Robert, F.G.S., *Putney Park, London.*
1867. 13. Kane, Sir R., 51, *Stephen's-green.*
1866. 14. Lalor, J. J., 6, *Upper Fitzwilliam-street.*
1856. 15. Lentaigne, John, M.D., *Great Denmark-street.*
1851. 16. Malahide, Lord Talbot de, F.R.S., *Malahide Castle, Malahide.*
1867. 17. Malet, Rev. J. A., D.D., S.F.T.C.D., *Trinity College.*
1838. 18. Mallet, Robert, C.E., F.R.S., *The Grove Clapham-road, London.*
1846. 19. Murray. B. B., *County Survey Office, Downshire-road, Newry.*
1859. 20. Ogilby, William, F.G.S., *Liscleen, Dunmanagh, Co. Tyrone.*
1852. 21. O'Kelly, Joseph, 14, *Hume-street.*
1849. 22. Sidney, F. J., LL.D., 19, *Herbert-street.*
1864. 23. Symes, Richard Glascott, 14, *Hume-street.*
1851. 24. Whitty, John Irvine, LL.D., 85, *Lower Mount-street.*

FELLOWS WHO HAVE PAID HALF LIFE COMPOSITION.*

1868. 1. Backhouse, M., 2, *Ontario-terrace.*
1854. 2. Barnes, Edward, *Ballymurtagh, Co. Wicklow.*
1866. 3, Bradley, Samuel, *Little Castle, Castlecomer.*
1832. 4. Bryce James, LL.D., M.A., F.G.S., *High School, Glasgow.*
1862. 5. Carter, T. S., *Watlington Park, Watlington, Oxfordshire.*
1854. 6. Clemes, John.
1870. 7. Cooke, Samuel, C.E., *Poona, Civil Engineering College, Bombay.*
1857. 8. Crawford, Robert, C.E., *care of Messrs. Peto and Betts*, 9, *Great George's-street, Westminster, S. W.*
1861. 9. Crosbie, William, *Ardfert Abbey, Ardfert, Tralee.*
1866. 10. Duffin, W. E. L'Estrange, *Maghera Rectory, Co. Down.*
1861. 11. Dunally, Lord, *Kilboy, Nenagh.*
1832. 12. Dunraven, Earl of, F.R.S., *Adare, Co. Limerick.*
1866. 13. Ellis, R. H., *The Hill, Monkstown.*
1869. 14. Enniskillen, Earl of, F.R.S., M.R.I.A., *Florence Court, Enniskillen.*
1866. 15. Graves, S. R., M.P., *Wavertree, Liverpool.*
1853. 16. Harkness, Professor, F.R.S., *Queen's College, Cork.*
1861. 17. Harte, W., C.E., *Buncrana, Donegal.*
1856. 18. Haughton, Lieut. John, R.A., *Bengal.*
1850. 19. Head, Henry, M.D., 7, *Fitzwilliam-square.*
1858. 20. Hill, J., C.E., *Ennis, Co. Clare.*
1862. 21. Hudson, R., F.R.S., F.L.S., *Clapham Common, London.*
1865. 22. Jacob Arthur, B.A., *Bromley, Kent.*
1839. 23. James, Sir H., Colonel, R.E., F.R.S., *Ordnance Survey Office, Southampton.*
1832. 24. Kearney, Thomas, *Pallasgreen, Co. Limerick.*
1857. 25. Keane, Marcus, *Beech Park, Ennis, Co. Clare.*

* EXTRACT FROM BY-LAWS.

"Any person not residing for more than sixty-three days in each year within twenty miles of Dublin, shall be a Fellow for Life, or until he comes to reside within the above distance, on paying to the Treasurers the sum of £5 5s.

"Any non-resident Life Fellow who shall reside within twenty miles of Dublin for more than sixty-three days in any one year, shall cease to be a Fellow, unless he shall either pay an additional composition of £5 5s., or shall pay a subscription of 10s. 6d. for each year in which he shall so reside for more than sixty-three days."

Elected.
1835. 26. Kelly, John.
1853. 27. Kinahan, George H., 28, *D'Olier-street.*
1862. 28. Kincaid, Joseph, Jun., C. E., 9, *Spring-gardens, London, S. W.*
1838. 29. Larcom, Major-General Sir Thomas, R. E., LL.D., F.R.S., *Heathfield, Fareham, Hants.*
1858. 30. Leech, Lieut.-Colonel, R. E., 3, *St. James's-square, London, S. W.*
1868. 31. Leonard, Hugh, 14, *Hume-street.*
1840. 32. Lindsay, Henry L., C.E., *Melbourne, care of J. Bower, Esq., C. E.*, 28, *South Frederick-street.*
1867. 33. Meadows, J. M'Carthy, *Athy.*
1840. 34. Montgomery, James E., M. R. I. A.
1856. 35. Molony, C. P., Capt., 25th Regt., Madras N. I., *per Messrs. Grinlay and Co.*, 3, *Corn-hill, London.*
1856. 36. Medlicott, Henry B., F. G. S., *Geological Survey of India, per Smith and Elder, Cornhill, London, E. C.*
1857. 37. M'Ivor, Rev. James, *Rectory, Moyle, Newtownstewart, Co. Tyrone.*
1865. 38. Morton, G. H., 7, *London-road, Liverpool.*
1845. 39. Neville, John, C.E., M.R.I.A., *Dundalk.*
1870. 40. Nicholls, Thomas, 32, *North Great George's-street.*
1868. 41. Nolan, Joseph, 14, *Hume-street.*
1832. 42. Renny, Henry L., R. E., *Canada.*
1870. 43. Rigby, Jason, C.E., 49, *Park-avenue, Sandymount.*
1865. 44. Scott, J. M., *Bengal Presidency College, Calcutta.*
1868. 45. Siree, P. H., C.E.
1854. 46. Smyth, W. W., F.R.S., *Jermyn-street, London.*
1865. 47. Steele, Rev. W., *Portora Royal School, Enniskillen.*
1857. 48. Tait, Alexander, C.E., *Queen's Elms, Belfast.*
1870. 49. Taylor, J. E., F. G. S., *Bracondale, Norwich.*
1832. 50. Tighe, Right Hon. William, *Woodstock, Innistiogue.*
1866. 51. Townsend, H. W. *Clonakilty.*
1866. 52. Wall, H. P., *Portarlington.*
1864. 53. Waller, G. A., 94, *Pembroke-road, Ball's-bridge.*
1853. 54. Webster, William B.
1861. 55. Whitney, C. J., *Brisbane, Queensland.*
1846. 56. Wilson, Walter, 51, *Stephen's-green.*
1864. 57. Wright, Joseph, 7, *Donegal-street, Belfast.*
1854. 58. Wyley, Andrew.
1857. 59. Wynne, Arthur B., F. G. S.

FELLOWS.

1861. 1. Andrews, William, 4, *Nassau-street.*
1867. 2. Baily, W. H., *Hume-street.*
1857. 3. Bandon, Earl of, D.C.L., *Castle Bernard, Bandon, Co. Cork.*
1859. 4. Barker, John, M. D., 83, *Waterloo-road.*
1861. 5. Barrington, C E., *Fassaroe, Bray.*
1862. 6. Barrington, E., *Fassaroe, Bray.*
1862. 7. Barton, Henry M., 4, *Foster-place.*
1864. 8. Bateman, C. W., LL. D., *West End, Mallow.*
1844. 9. Bective, Earl of. *Headfort, Kells.*
1862. 10. Bennett, E., M. B., 2, *Upper Fitzwilliam-street.*
1857. 11. Bolton, George, Jun., 6, *Ely-place.*
1861. 12. Bolton, H. E., 6, *Ely-place.*
1864 13. Bradshaw, G. B.
1831. 14. Brady, Right Hon. Maziere, 26, *Upper Pembroke-street.*
1868. 15. Brien, Charles H., *Board of Public Works, Custom-house.*
1870. 16. Brett, H. C. C. E., 8, *Harrington-street.*
1840. 17. Callwell, Robert, M. R. I A., 25, *Herbert-place.*
1857. 18. Carte, Alexander, M. D., F. L. S., *Royal Dublin Society.*

Elected.
1867. 19. Clarke, G. R., *Public Works Department, Lucknow, India.*
1862. 20. Close, Rev. Maxwell, *Newtown Park, Blackrock.*
1858. 21. Cotton, Charles, P., C. E., 11, *Lower Pembroke-street.*
1862. 22. Cousins, A. L., C. E.
1863. 23. Crook, Rev. R., LL. D., *Wesleyan College, Belfast.*
1868. 24. Cruise, R. J., *Camagh, Drumlish, Co. Longford.*
1853. 25. De Vesci, Lord, *Abbeyleix House, Abbeyleix.*
1863. 26, Dixon, G., 32, *Holles-street.*
1849. 27. Downing, Samuel, LL. D., C. E., *Trinity College.*
1852. 28. Doyle, J. B., *Derrymore House, Newry.*
1867. 29. Dunscombe, Clement, *King William's Town, Co. Cork.*
1865. 30. Fleming, John M., *The Barracks, Clonmel.*
1866. 31. Foot, A. W., M. D., 21, *Lower Pembroke-street.*
1867. 32. Forster, R., *University Club.*
1858. 33. Gages, Alphonse, M. R. I. A., 51, *Stephen's-green.*
1864. 34. Gahan, A., C. E., *Cavan.*
1849. 35. Galbraith, Rev. Joseph A., F. T. C. D., *Trinity College.*
1865. 36. Gibson, John, C. E., *Stapleton-place, Dundalk.*
1867. 37. Gore, J. E., C. E.
1865. 38. Gray, R. A., C. E., 5, *Palmerstown Villas, Upper Rathmines.*
1859. 39. Green, Murdock, 52, *Lower Sackville-street.*
1862. 40. Gribbon, C. P., 72, *Stephen's-green.*
1831. 41. Griffith, Sir R., Bart., LL. D., F. G. S., 2, *Upper Fitzwilliam-place.*
1857. 42. Hampton, Thomas, C. E., 6, *Ely-place.*
1866. 43. Heron, Robert, *Harrow House, Ballybrack.*
1861. 44. Hudson, A., M. D., *Merrion-square.*
1870. 45. Hull, M. A., F. R. S., Edward, 14, *Hume-street.*
1865. 46. Hutton, T. M., 118, *Summer-hill.*
1852. 47. Jellett, Rev. Professor, F. T. C. D., M. R. I. A., 9, *Trinity College.*
1842. 48. Jennings, F. M., M.R. I. A., *Brown-street, Cork.*
1862. 49. Kinahan, G., J. P., *Roebuck-hill, Dundrum.*
1866. 50. Knapp, W. H., C. E., 5, *Summer-hill Road, Kingstown.*
1865. 51. Leech, John, C. E., 6, *Ely-place.*
1831. 52. Lloyd, Rev. Humphrey, D. D., F. R. S., Provost, T. C. D., *Provost's House.*
1863. 53. Macalister, A., M. D., 19, *Leinster-road, Rathmines.*
1855. 54. M'Causland, Dominick, 12, *Fitzgibbon-street.*
1861. 55. M'Comas, A., 23, *Rathmines-road.*
1863. 56. M'Donnell, Alexander, C. E., *St. John's, Inchicore.*
1851. 57. M'Donnell, John, M. D., 4, *Gardiner's-row.*
1837. 58. Mollan, John, M. D., 8, *Fitzwilliam-square.*
1859. 59. Moore, Joseph Scott, J. P., *Hume-street.*
1831. 60. Nicholson, John, M. R. I. A., *Balrath House, Kells.*
1856. 61. O'Brien, Octavius, 23, *Kildare-street.*
1865. 62. Ollis, G., *The Camp, Aldershott.*
1864. 63. Palmer, Sandford, *Roscrea.*
1857. 64. Porter, William, C. E., *Leinster Club, Clare-street.*
1865. 65. Radley, John, *Gresham Hotel, Sackville-street.*
1864. 66. Reynolds, J. Emerson, *Royal Dublin Society.*
1857. 67. Reeves, R. S., 22, *Upper Mount-street.*
1861. 68. Roberts, W. G., *Nenagh, Co. Tipperary.*
1862. 69. Rowan, D. J., C. E., *Athlone.*
1864. 70. Russell, H.
1852. 71. Smith, Robert, M. D., 63, *Eccles-street.*
1852. 72. Sanders, Gilbert, M. R. I. A., *The Hill, Monkstown.*
1854. 73. Scott, Robert H., F. G. S., *Meteorological Office*, 116, *Victoria-street, London.*
1866. 74. Stewart, H., M. D., *Lucan.*
1859. 75. Stokes, William, M. D., F. R. S., 5. *Merrion-square, N.*
1861. 76. Stoney, Bindon, C. E., 42, *Wellington-road.*
1862. 77. Taylor, Colonel Meadows, M. R. I. A., *Oldcourt, Harold's-cross.*
1864. 78. Tichborne, C. R. C., *Apothecaries' Hall, Mary-street.*

1869. 79. Traquair, R. H., M. D., 51, *Stephen's-green.*
1859. 80. Waldron, L., LL. D., *Ballybrack.*
1863. 81. Westropp, W. H. S., M. R. I. A., 2, *Idrone-terrace, Blackrock.*
1863. 82. Williams, Richard Palmer, 38, *Dame-street.*
1851. 83. Wright, Edward P., LL. D., M. R. I. A., 5, *Trinity College, Dublin.*

ASSOCIATES FOR THE YEAR.

1. Clibborn, J., 13, *Leeson-park.*
2. Dwyer, F., 45, *Upper Sackville-street.*
3. Edmondson, J. W., *Foxrock.*
4. Greene, J. F., 63, *Lower Gardiner-street.*
5. Griffith, J. P., 2, *Trinity College.*
6. Heath, F., *Harold's-cross.*
7. Neville, E. K., 18, *Trinity College.*
8. Purcell, Gervaise, 71, *Harcourt-street.*
9. Ryan, J. H., 34, *Leeson-park.*
10. West, C. D., *St. Patrick's Deanery.*
11. White, H. B., *Royal Dublin Society.*

No. II.

LIST OF MEMBERS GAINED AND LOST,

CORRECTED TO JANUARY 30, 1870.

FELLOWS GAINED.

Half Life.

1. Nicholls, Thomas, C. E., 32, *Great George's-street, N.*
2. Taylor, J. E., F. G. S., *Bracondale, Norwich.*
3. Cooke, Samuel, B. A., C. E., *Poona Civil Engineering College, Bombay.*
4. Rigby, Jason, C. E., 49, *Park-avenue, Sandymount.*

Annual.

1. Traquair, Ramsay H., M. D., 51, *Stephen's-green.*
2. Hull, Edward, M. A., F. R. S., Director Geological Survey Ireland, 14, *Hume-street.*
3. Brett, Henry C., C. E., 8, *Harrington-street.*

FELLOWS LOST.

Life.

1. Jukes, Joseph B., F. R. S., 51, *Stephen's-green.*	Deceased.
2. Haliday, A. H., A. M., *Harcourt-street.*	Do.
3. King, Hon. James, *Mitchelstown*	Do.
4. Luby, Rev., Thomas, D. D., S. F. T. C. D., *Trinity College.*	Do.

Half Life.

1. Ormsby, Montagu H., LL. D., C.E., Geol. Survey, India.	Do.

Annual.

1. Croker, Charles P., M. D, 7, *Merrion-square, W.*	Do.
2. Good, John, *City-quay.*	Do.
3. Apjohn, James, M. D., *Blackrock.*	Resigned.
4. Battersby, Francis, M. D., 15, *Warrington-place*	Do.
5. Brownrigg, W. B., *Branockstown.*	Do.
6. Porte, George, *Beggarsbush-road.*	Do.
7. Thresh, J. T., *Old Palace, Richmond.*	Do.

State of the Society at the commencement of—

	Year 1869.	Year 1870.
Honorary Fellows,	15	15
Corresponding do.,	6	6
Life do.,	84	83
Annual, do.,	87	83
	192	187

No. III.

DONATIONS RECEIVED TO JANUARY 31, 1870.

Amsterdam.—Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen, 1869. D. III.

——— Jaarbock vande Koninklijke Akademie van Wetenschappen, 1868.

——— Koninklijke Akademie van Wetenschappen te Amsterdam. Proces-Verbaal, van de. Gewone Vergadering der Afdeeling Natuurkunde, 1868–69 (No. 1).

Albany.—18th and 19th Annual Reports of the Regents of the University of the State of New York on the Condition of the State Cabinet of Natural History, &c.; and 47th, 48th, and 49th Annual Reports of the Trustees of the New York State Library.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. XX Band, May–October, 1868; XXI Band, 1 Heft, 1869.

——— Zeitschrift fur die Gesammten Naturwissenschatten. For the year 1868. (10 parts.)

——— 2 Maps.—Das Curische Haff, and Ost-Samland.

Brussels.—Bulletins de l'Académie Royale des Sciences et des Lettres. 2m Ser. T. XXV. & XXVI. 1868.

——— Annuaire de l'Académie Royale des Sciences, &c. 1859.

Brunn.—Verhandlungen des Naturforschenden Vereines in Brunn. VI. Band. 1867.

Boston.—Annual Report of Trustees of the Museum of Comparative Zoology at the Harvard College, Cambridge. 1866.

——— Memoirs read before the Boston Society of Natural History. Vol. I., Parts 3 and 4.

——— Annual of the Boston Society of Natural History. 1868 and 1869.

——— Condition and Doings of the Boston Society of Natural History. 1867 and 1868.

——— Occasional Papers of the Boston Society of Natural History. (Harris.)

Calcutta.—Asiatic Society of Bengal. President's Address, January, 1869.

Cambridge, U. S.—Contributions to the Fauna of the Gulf Stream at great depths, by L. F. de Pourtales.

——— The Fossil Cephalopods of the Museum of Comparative Zoology, by R. Hyatt.

Dublin.—The Journal of the Historical and Archæological Association of Ireland, Vol. I. Nos. 4, 5, 6.

——— The Journal of the Royal Dublin Society, No. 38.

——— Geological Survey of Ireland. Explanations to accompanying Sheets 105 and part of 114, by G. H. Kinahan.

Dresden.—Sitzungs-Berichte der Naturwissenschafthchen Gesellschaft Isis in Dresden, Nos. 7–12.

Falmouth.—36th Annual Report of the Royal Cornwall Polytechnic Society, 1868.

Glasgow.—Transactions of the Geological Society of Glasgow, Vol. III., Part 1.

Giefsen.—Dreizehntte Bericht der Oberhessischen Gesellschaft fur Natur-und Heilkunde, April, 1869.

Hanau.—Bericht der Wetteranischen Gesellschaft fur die Gesammte Naturkunde, October, 1863–December, 1867.

London.—Proceedings of the Royal Geographical Society, Vol. XIII., Nos. 2, 3, and 5.

——— Journal of ditto, Vol. XXXVII.; and Address delivered at Anniversary Meeting, May, 1869.

London.—The Royal Society's Proceedings, Vol. XVII., Nos. 110, 111, 112, 113, 114.
——— The Flora and Fauna of the Silurian Period, by J. J. Bigsby, M. D.
——— The Linnean Society, Vol. XI., Nos. 49, 50, 51; Vol. X., No. 46; Report of Anniversary Meeting, 1869.
——— The Geological Society's Journal, Vol. XXV., No. 98; Vol. XXV., Parts 3, 4.
——— The Palæontographical Society, Vol. XXII.
——— The East Indian Association's Journal, No. II.
——— The Literary and Philosophical Society of Manchester, 3rd series, Vol. III.
——— The Zoological Society—Proceedings of the Scientific Meetings for the year 1869 and for 1868, Part I.
——— Institute of Civil Engineers' Proceedings, Vols. XXVII. and XXVIII.
——— Royal Institute of Great Britain—Proceedings, Vol. V., Nos. 49 and 50; Report, 1869.
——— Report of the Committee of the Meteorological Office, No. 2.
Lausanne.—Bulletin de la Société Vaudoise des Sciences Naturelles, Vol. X., No. 61.
Louvaine.—Annuaire de l'Université Catholique de Louvaine. 1867-69.
La Haye.—Archives Neerlandaises des Sciences Exactes et Naturelles, Tom. III., Liv. 3-5.
Liverpool.—Transactions of the Historic Society of Lancashire and Cheshire, Vol. VIII., 1867-68.
——— Abstract of the Proceedings of the Liverpool Philosophical Society, 1868-69.
Lyons.—Annales des Sciences Physiques et Naturelles &c., de Lyon, Tome XI., 1867.
Lewis.—Geologists' Association:—1. Reports of Excursions, 2. List of Members; 3. On the chief groups of the Cephalopods, 1869.
Leeds.—Annual Report of Leeds Philosophical Society, 1868-69.
München.—Sitzungsberichte der Konigl, bayer Académié der Wissenschaften zu München, 1868, II. Heft. 1, 2, 3, and 4; 1869, I. Heft. 3.
Manchester.—Proceedings of the Literary and Philosophical Society of Manchester. Vols. V., VI., and VII.
Madison, Wis.—Transactions of the Wisconsin State Agricultural Society, and Address by D. B. Reid, Vol. VII.
Montreal.—The Canadian Naturalist and Geologist, Vol. III., Nos. 1, 4, and 5; Vol. IV., No. 2.
Milano.—Memoire del Reale Instituto Lombardo di Scienze e Lettere, Vol. XI. (Il della Serie III.)
——— Rendiconti, Vol. I., Parts 11-20; Vol. II., Parts 1-10; Vol. II., Parts 11-16.
——— Solenni Adunanze del R. Instituto Lombardo di Scienze e Lettere, 1868.
New Haven.—The American Journal of Science and Arts, Vol. XLVII., Nos. 140 and 141; Vol. XLVIII., Nos. 142 and 143.
New York.—Annals of the Lyceum Natural History of New York, Vol. VIII., Nos. 15-17; Vol. IX., Nos. 1-4.
Paris.—Annales des Mines au Recueil, Tome XIV.
Philadelphia.—Proceedings of the American Philosophical Society, Vol. X., Nos. 78, 79; Vol. XI., No, 81.
——— Transactions of ditto, Vol. XIII., Part 3.
Plymouth.—Annual Report and Transactions of the Plymouth Institute, Vol. III.; Part 2.
Stuttgart.—Wurtembergische Naturwissenschaftliche Jareshefte, 1868 and 1869.
Salem.—Proceedings of the Essex Institute, Vol. V., Nos. 5 and 6, 7 and 8.
——— Memoirs of the Peabody Academy of Science, Vol. I., Part I.
St. Louis.—Transactions of the Academy of Science of St. Louis, Vol. II.
Toronto.—The Canadian Journal of Science, Literature, &c., Vol. XII., No. 2.
Vienna.—Jahrbuch der Kaiserlich-Koniglichen Geologischen Reichsanstalt Jahrgang, 1868, XVIII. Band.
——— Verhandlungen der K. K. Geologischen Reichsanstalt, Jahrgang 1868, Nos. 1-18.
Washington.—Smithsonian Report for 1867.
——— Report of Natural Academy of Science.
Zurich.—Vierteljahrsschrift der naturforschenden Gesellschaft in Zurich, 4 Parts, 1867. 4 Parts, 1868.

No. VI.

SOCIETIES AND INSTITUTIONS TO WHICH THE JOURNAL OF THE ROYAL GEOLOGICAL SOCIETY OF IRELAND IS SENT.

ABERDEEN, .	University Library.
ALBANY, . .	State Library, New York.
AMSTERDAM, .	Royal Academy of Sciences,
ANTWERP, . .	Société Palæontologique de Belgique.
BELFAST, . .	Queen's College Library.
BERLIN, . .	Royal Academy of Sciences.
	German Geographical Society.
	German Geological Society, per Bessersche Buchhandlung, *Behren-str.*, 7, *Berlin*.
BOLOGNA, . .	Accademia delle Scienzi delle Istituto.
BORDEAUX, .	Imperial Academy of Sciences.
BOSTON, . .	American Academy.
	Natural History Society.
BRISTOL, . .	Institution for the Advancement of Science, Literature, and the Arts.
BRÜNN, . .	Naturforschende Verein.
BRUSSELS, . .	Academy of Sciences.
CAEN, . . .	Société Linnéenne Normandie.
CALCUTTA, .	Asiatic Society.
	Public Library.
	Geological Survey of India.
CAMBRIDGE, .	Philosophical Society.
	Trinity College Library.
CANTERBURY, NEW ZEALAND,	Geological Survey.
COPENHAGEN, .	Royal Society of Science.
CORK, . . .	Queen's College Library.
	Royal Institution.
DIJON, . .	Academy of Sciences.
DRESDEN, . .	The "Isis" Society.
DUBLIN, . .	Royal College of Surgeons' Library.
	Royal Irish Academy.
	University Library.
	Royal Dublin Society.
	Natural History Society.
	Ordnance Survey Library.
	Professor Sullivan, as Editor of the "Atlantis."
	Geological Survey of Ireland.
	Institution of Civil Engineers.
EDINBURGH, .	Royal Society.
	Wernerian Society.
	Royal Scottish Society of Arts.
	University Library.
	Society of Antiquaries.
	Advocates' Library.
FALMOUTH, .	Royal Cornwall Polytechnic Society.
FLORENCE, . .	Society of Physics and Natural History.
GALWAY, . .	Queen's College Library.
GENOA, . .	Society of Physics.
GLASGOW, . .	University.
	Geological Society.
GÖTTINGEN, .	University.

HAARLEM, . .	Société Hollandaise des Sciences, per B. Quarritch, 15, *Piccadilly, London.*
HALLE, . .	Naturwissenschaftliche Verein für Sachsen und Thüringen, per Antons Buchandlung, *Halle.*
HANAU, . .	Oberhessische Gesellschaft der Natur-und Heil-kunde.
HANOVER, . .	Royal Library.
KILKENNY, .	Archæological Society.
KÖNIGSBERG, .	Königlich Physicalisch-Oekonomische Gesellschaft.
LAUSANNE, .	Société Vaudois des Sciences Naturelles.
LEEDS, . . .	Geological and Polytechnic Society of the West Riding of Yorkshire.
	Philosophical and Literary Society.
LEIPSIC, . .	Royal Society of Sciences (Saxony).
	University.
LIVERPOOL, . .	The Literary and Philosophical Society.
	Historic Society of Lancashire and Cheshire.
	Geological Society, The Royal Institution, *Colquitt-street.*
LONDON, . .	Geological Survey, *Jermyn-street.*
	British Museum.
	Society of Arts, *John-street, Adelphi.*
	Royal Institution, *Albemarle-street.*
	Royal Society, *Burlington House.*
	Geological Society, *Somerset House.*
	Linnean Society, *Burlington House.*
	Royal Geographical Society, 15, *Whitehall-place.*
	Civil Engineers, Institution of, 25, *Great George's-street, Westminster.*
	Royal Asiatic Society, 5, *New Burlington-street.*
	Royal College of Surgeons, *Lincoln's Inn.*
	Zoological Society, 11, *Hanover-square.*
	Athenæum, 14, *Wellington-street, Strand, London, W. C.*
	Anthropological Society, 4, *St. Martin's-place, London, W. C.*
LYONS, . . .	La Société Impériale d'Agriculture, d'Histoire Naturelle, et des Arts Utiles.
	Société Linnéene.
	Academie Impériale, per Treuttel & Wurtz, 19, *Rue de Lille, Paris.*
MADRID, . .	Academia de Ciencias.
MANCHESTER, .	Literary and Philosophical Society of. [Sec. R. C. Christie.]
	Geological Society.
MELBOURNE, .	Philosophical Institute of Victoria.
	The Public Library, per Bain and Co., 1, *Haymarket, London.*
	The Royal Society.
MILAN, . . .	Reale Istituto Lombardo di Scienzi.
MISSOURI, . .	State Survey and University, *Geological Rooms, Columbia, U. S. A.*
MODENA, . .	Institute of Science.
MONTREAL, . .	Natural History Society.
MUNICH, . .	Royal Academy of Science (2 copies).
NEUCHATEL, .	Société des Sciences Naturelles.
NEW HAVEN, U. S. A.,	The Editors of Sillinan's Journal of Science and Art.
NEW YORK, .	Lyceum of Natural History.
OXFORD, . .	Bodleian Library.
	Ashmolean Society.
PALERMO, . .	Accademia di Scienzi e Lettere.
PARIS, . . .	Ecole Polytechnique.
	Geological Society.
	L'Ecole Impériale des Mines.
	Institute of France.
	Bibliothéque Impériale.
	Jardin des Plantes, Bibliothéque.

PHILADELPHIA,	American Philosophical Society.
	Academy of Natural Sciences, per Trübner and Co.
PLYMOUTH, .	The Plymouth Institution and Devon and Cornwall Natural History Society.
PRESBURG, .	Der Verein für Naturkunde.
QUEBEC, . .	Literary and Historical Society.
ROME, . . .	The Vatican Library.
ROUEN, . .	Academy of Sciences.
ST. ANDREWS, .	University Library.
ST. LOUIS, . .	Academy of Sciences.
ST. PETERSBURG,	Imperial Academy.
	Central Physical Observatory of Russia.
	Russisch-Kaiserliche Mineralogische Gesellschaft.
STOCKHOLM, .	Royal Academy of Science, per Longmans and Co., *Paternoster-row, London;* and Sampson and Wallis, *Stockholm.*
	Geological Survey of Sweden.
STRASBOURG, .	Société des Sciences Naturelles.
STUTTGART, . .	Verein für vaterländische Naturkunde.
TORONTO, C. W.,	Canadian Institute, per Thomas Henning, Esq.
TOULOUSE, . .	Academy of Sciences.
TRURO, . . .	Royal Institute of Cornwall.
TURIN, . . .	Royal Academy.
UPSALA, . .	Royal Society of Sciences.
VIENNA, . .	Imperial Academy of Sciences.
	Prof. W. Haidinger, of Vienna, as Editor of the "Jahrbnch der K. K. Geologischen Reiche-anstalt."
	K. K. Zoologisch-botanische Gesellschaft, per Braümuller and Co., *Vienna.*
WASHINGTON, .	Smithsonian Institute Library, per W. Wesley, Esq., 2, *Queen's Head Passage, Paternoster-row, London, E. C.*
WINDSOR, . .	The Royal Library.
ZURICH, . . .	Naturforschende Gesellschaft.

No VII.

ABSTRACT OF TREASURER'S ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1869.

DR.		£ s. d.
To Balance in Royal Bank, to 31st December, 1868,		1 11 7
— Subscriptions received during 1869:—		
Annual,	£84 17 0	
Entrance,	1 1 0	
		85 18 0
— Dividends on Stock for half-year ending 5th April, 1869:—		
On £272 4*s.* 6*d.*,	3 15 3	
Do., to 10th October, 1869, on £308 8*s.* 2*d.*,	4 10 7	
		8 5 10
— Received, per Dr. Haughton, for sale of sundry Books,	100 0 0	
— Do., Robert Callwell, Esq., do.,	30 0 0	
		130 0 0
— Received for Sundries, Cases, &c.,	4 5 0	
— Do., do.,	7 0 0	
— Do., do.,	3 15 0	
		15 0 0
		£240 15 5

CR.		£ s. d.
By Paid for Royal Bank Cheque Book,		0 4 2
— Do. Balance due to Dr. Haughton,	£2 17 5	
— Do. do., do. Mr. Galbraith,	0 12 2	
		3 9 7
— Petty Expenses for 1869,	8 6 6	
— Do., do.,	7 1 3	
— Do., do.,	6 6 8	
		21 14 5
— Williams and Norgate's Account,	3 16 6	
— Eaton and Co., do.,	1 3 6	
		5 0 0
— Hanlon, for Woodcuts,	2 5 0	
— Do., do.,	1 15 0	
		4 0 0
— M'Cartney, Reporter,		3 3 0
— Assistant Secretary, half-year to 30th June, 1869,	5 0 0	
— Do., do., to 31st December, 1869,	5 0 0	
		10 0 0
— Collector's Commission and Postage,	3 13 3	
— Do.,	0 15 6	
		4 8 9
— Mr. Gill's Printing Account,	97 5 7	
— Do., do.,	31 5 4	
— Do., do.,	4 6 0	
		132 16 11
— Invested in Government 3 per Cents.:—		
18th March, 1869,	6 19 5	
8th April, 1869,	7 0 0	
25th June, 1869,	3 15 0	
18th August, 1869,	30 0 0	
		47 14 5
— Balance in Bank, to December 31, 1869,		8 4 2
		£240 15 5

We have compared the foregoing Account with the Vouchers and with the Bank Books, and find it correct.

SAMUEL HAUGHTON.
C. R. C. TICHBORNE.

END OF VOL. II., N. S.